Studies in Systems, Decision and Control 282

Aleksei V. Bogoviz *Editor*

Complex Systems: Innovation and Sustainability in the Digital Age

Volume 1

Springer

Studies in Systems, Decision and Control

Volume 282

The series "Studies in Systems, Decision and Control" (SSDC) covers both new developments and advances, as well as the state of the art, in the various areas of broadly perceived systems, decision making and control–quickly, up to date and with a high quality. The intent is to cover the theory, applications, and perspectives on the state of the art and future developments relevant to systems, decision making, control, complex processes and related areas, as embedded in the fields of engineering, computer science, physics, economics, social and life sciences, as well as the paradigms and methodologies behind them. The series contains monographs, textbooks, lecture notes and edited volumes in systems, decision making and control spanning the areas of Cyber-Physical Systems, Autonomous Systems, Sensor Networks, Control Systems, Energy Systems, Automotive Systems, Biological Systems, Vehicular Networking and Connected Vehicles, Aerospace Systems, Automation, Manufacturing, Smart Grids, Nonlinear Systems, Power Systems, Robotics, Social Systems, Economic Systems and other. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution and exposure which enable both a wide and rapid dissemination of research output.

** Indexing: The books of this series are submitted to ISI, SCOPUS, DBLP, Ulrichs, MathSciNet, Current Mathematical Publications, Mathematical Reviews, Zentralblatt Math: MetaPress and Springerlink.

More information about this series at http://www.springer.com/series/13304

Aleksei V. Bogoviz
Editor

Complex Systems: Innovation and Sustainability in the Digital Age

Volume 1

Springer

Editor
Aleksei V. Bogoviz
Department of Social Sciences
National Research University Higher School
of Economics
Moscow, Russia

ISSN 2198-4182 ISSN 2198-4190 (electronic)
Studies in Systems, Decision and Control
ISBN 978-3-030-44702-1 ISBN 978-3-030-44703-8 (eBook)
https://doi.org/10.1007/978-3-030-44703-8

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface to Volume I: Perspectives on Innovation and Sustainability in Complex Systems

This volume presents a timely collection of chapters addressing the issues of innovative and sustainable development of complex systems in the era of digital transformations. Presenting cutting-edge contributions by scientists, engineers, and field experts, this book provides the readers with a coherent framework for understanding the essence of complex systems and the nature of digital transformations, analyzes challenges and patterns of innovative development, as well as provides sustainability insights and best practices, resulting in the most extensive coverage of the topic available.

Divided into five parts, the volume, first of all, focuses on entrepreneurship, human capital development, and management approaches in an age of increasing complexity. Unique contributions provide perspectives on the contemporary highly complex and uncertain environments, in which business organizations have to operate regardless of their size and industry affiliation. Particularly, scholars describe an array of analytical and methodological approaches used for building and sustaining a technological potential of a business entity, developing human resources, increasing competitiveness, and improving management efficiency.

Second, social science scholars conduct a broad interdisciplinary analysis of collaboration mechanisms for supporting and accelerating sustainable development in complex systems through a collection of different theories that reveal novel and effective approaches. Their research covers successful intervention strategies, models of sustainable development, economic security in regional development, productive forces, sustainable green development, etc.

Third, the special focus is on how complex economic systems innovate and sustain themselves, taking into account the existing and expected digital changes and challenges. A separate short section provides a comparative analysis of information and communication technologies, their penetration, and creation of uneven information environments, enabling readers to explore the tremendous impact of digital technologies on sustainable economic development in various parts of the world.

Fourth, the authors explore the whole array of issues from the real-world practice, providing a number of case studies on the adoption of technological, service, and business model innovations in complex systems, with an emphasize on achieving higher sustainability.

Finally, this volume presents a multidisciplinary collection of original contributions on researching, building, and maintaining sustainable agricultural and food systems, relying on the developed insights, perspectives, and methodology of complex systems science.

There is no doubt that innovative and sustainable development of complex systems is an urgent research field, and this volume makes a unique contribution. Due to its practical focus, the book appeals to practitioners and policymakers working in economics, management, business, political science, and sustainability, not just academics. This is also a valuable resource for graduate students interested in the multidisciplinary research on complex systems research.

Moscow, Russia
January 2020

Aleksei V. Bogoviz
aleksei.bogoviz@gmail.com

Contents

Case Studies: Sustainability and Innovation in Agricultural and Food Systems

Entrepreneurship, Human Capital, and Management in an Age of Complexity

Startup Management in Social Entrepreneurship: A Strategy for Building Technological Potential and Overcoming of the Trap of the Average Income

Olga A. Fiofanova

Abstract The management practices of social entrepreneurship startups, institutional conditions of their support in connection with the adoption of a draft law to the social entrepreneurship in Russia are analyzed. The startups in the field of social entrepreneurship in economic activity types are analyzed based on the Rosstat data. The factors creating favorable environments for the development of startups in the category of the social entrepreneurship based on the Startup Ecosystem Ranking data are analyzed. Key trends in the investment support for social startups areas based on the SAP UP (Social Entrepreneur Fellowship) data in Russia are also discussed. In addition, the authors focus on competence deficiencies of the leaders of social entrepreneurship projects undergoing acceleration and business incubation support. The factors of effective management of social startups are determined: market niche and type of economic activity in social services, project team's involvement in acceleration programs and management of team competency deficit, investment support in the first stage of startup development.

Keywords Social entrepreneurship · Startup · Investment support · Independent assessment of the social service quality · Acceleration programs for startups · Project management in the social sphere · Strategy of formation of technological potential and overcoming of a trap of the average income

1 Introduction

Social entrepreneurship as business projects, aimed at improving society, is a phenomenon explored in various scientific aspects. The relevance is the managerial aspect of social entrepreneurship in terms of a set of questions: what are the competencies of the leader (manager) of a social project; what factors of startup ecosystems affect the development management of social startups; and what factors determine

O. A. Fiofanova (✉)
The Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
e-mail: fiofanova@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_1

the investment support for startups? The development of open-data systems Startup Ecosystem Ranking [13], Social Entrepreneur Fellowship [12], and data from acceleration and business incubation programs provide opportunities for factor analysis of the management of startups in the social sphere.

In the institutionalization of social entrepreneurship, its legal status (the consolidation of the legal status of "social entrepreneur" and "social enterprise"; the approval of the list of social services in this area; the determination of the types of support by state authorities and local governments of small and medium-sized enterprises, engaged in activities related to social entrepreneurship. The law [11] creates new organizational and managerial prospects for the development of social entrepreneurship through public-private partnerships in education, culture, social protection, through the provision of conditions for access to the public procurement of social entrepreneurs.

The formation of a favorable institutional environment for startups is the task of the country and state. According to the *Startup Ecosystem Ranking* (ranking countries according to the favorable environment for creating and growing startups), the leaders are Berlin, Singapore, Houston, Tel Aviv, London, and Paris [13].

The phenomenon of social entrepreneurship is also interesting for research, as it develops a new type of leader: the organizers of socially responsible business, who form strategies for the technological potential of innovation, solving universal human problems of quality of life and leading initiatives for social, economic, cultural, leisure, and educational improvements in their city or region, breaking the middle-income trap.

In connection with the spread of acceleration and incubation program practices for entrepreneurs, the social entrepreneurship phenomenon is also of research interest. It requires new types of professional and social competencies, and entrepreneurs with deficits in these areas are encouraged to master competence development and organizational development of the business through acceleration, incubation, and mentoring programs.

The third aspect, which is interesting for the phenomenon of social entrepreneurship, is: Who is ready to invest in projects and to what extent? In order to study this aspect, we focus on the index of the physical volume of investments in fixed assets by the type of economic activity [6, 10]. For example, one could consider the Starter program (organized by Social Impact), the Social Entrepreneur Fellowship program (organized by SAP) [12]. Infrastructure for supporting start-ups (in particular, start-ups of social entrepreneurship) is being created. What types of deficits (competence, organizational, institutional) do social entrepreneurs face, and what acceleration support and mentoring support programs do they choose?

Data analytics on all the raised questions will allow us to see social entrepreneurship in a new way, as a dynamically developing phenomenon.

2 Materials and Methods

The study is based on the concepts of *Technological Potential* and *Middle-Income Trap* [7]—the concept of developing the technological potential of innovative social projects (start-ups) and overcoming the middle-income trap. In these concepts, the middle-income trap is analyzed as a result of the inability to transform the innovative potential of technology implementation into the potential of construction—changing socio-cultural institutions to make decisions about change management. This kind of transformation is undertaken by the founders of social projects—social entrepreneurs. This phenomenon is subject to a more thorough study because this kind of transformation of the technological potential is based on a special kind of leadership, organizational, entrepreneurial competencies of the founders of social start-ups.

Modern researchers believe that the "middle-income trap is a consequence of the inability to transform the potential for the realization of technologies into the potential for construction" (the transformation of sociocultural institutions) [7]. The study of this connection on the example of the study of social startups and the study of the competencies of social entrepreneurs have become the subjects of analysis in this paper.

The research methods included the content analysis of social entrepreneurs' projects submitted to the competition of social innovation projects, focus group interviews, conducted as part of surveys at the II Forum of Social Innovations, as well as a discourse analysis of speakers' speeches at expert sites of the Social Innovations Forum and in the media.

In total, 123 representatives of the organizations of social entrepreneurship participated in the study. The most famous among them are:

Airbnb—a digital service for booking short-term accommodation with residents of the place where the traveler goes at a bargain price.

GlobalGiving, *DonorSearch*—a coordination service that connects beneficiaries and donors.

Foxford—a digital educational service for schoolchildren.

The Greenhouse of Social Technologies is an online navigator for implementing social startups in the form of online applications.

Goodwillion is a meeting auction platform where anyone can offer a meeting to help those in need.

The platforms for support of social entrepreneurship included Newsonline24, Startup, Network, SprintX, and Student Startup Support Platform—Molo.Co.

A study on the entry of social entrepreneurs into educational programs was also conducted:

- OtUS—Skolkovo Open University;
- Social Impact Award as an online course for social businesses in the early development stages);
- The Academy of Social Entrepreneurship as a development in the region of an ecosystem of a community of effective social entrepreneurs;

- Acceleration program "Social Innovation";
- School of Social Entrepreneurship (mini MBA for social entrepreneurs).

The results of the survey studying social entrepreneurs allowed us to identify and evaluate the effect of the competent development of the founders of social startups as an effect of educational programs.

Using the focus group method, we analyzed both the risks that social entrepreneurs are ready to take due to the unavailability of the institutional environment, but also the high technological potential of an innovative startup. The identified risk factors were systematized into three groups: space, time, and politics, which allowed us to identify strategies for overcoming institutional traps and realize the technological potential of a startup.

3 Results

The results of the study on the current competencies of social entrepreneurs revealed that according to the implementation of educational programs, social entrepreneurs enter the programs (both as part of the competitive entry, massive online courses, and educational platforms) upon recognizing their lack of competencies for managing a full-cycle project, lack of legal knowledge in the implementation of a social project, lack of knowledge on how to monetize a social project and overcome institutional traps, inability to attract investor or crowdfunding funds, or insufficient expertise on technology or innovation transfer projects (e.g., franchise contracts, network programs).

According to the results of the survey (n = 112 people), 100% of social entrepreneurs believe that the programs allowed them to raise the level of necessary competencies; 60.7% believe that the programs helped establish useful social contacts in the community of social entrepreneurs; 28.5% of social entrepreneurs believe that during the training period of the programs, they managed to find mentors who assisted in the expert support of their social project; none of the social entrepreneurs think that the programs helped them find investors or identify ways to attract investors to the project who could contribute to the development of the technological potential of a startup.

That is, according to social entrepreneurs, the programs of educational acceleration support should solve not only training tasks but also coordination tasks—providing a meeting place for potential investors and crowd funders with social entrepreneurs and with experts on developing the technological potential of projects. 50% of social entrepreneurs believe that the organizers of educational (acceleration) programs need to change control forms, based on the results of mastering educational programs: to not use tests for testing knowledge but cases for solving real problems of developing startups. The format of mentoring is to defend projects for developing startups.

Among social entrepreneurs, the demand for specialized educational programs of a communication orientation has also increased: "How to tell the media and TV about the project" and "How to build communications with authorities about supporting the project." The lack of competencies in this context is noted by 83.0% of social entrepreneurs. Many social entrepreneurs believe that a specialized program or precise information in the form of a digital service is needed ("The infrastructure of competitive support for social startups"). Such programs have not yet been presented in the service market. Nevertheless, to realize the technological potential of social startups, such competencies of social project leaders as constructing institutional changes are essential.

Thus, through the analysis of the demand of social entrepreneurs for educational (acceleration) programs, one can see how the leaders of a new type are formed. The profile of this type of leader is focused on organizational, legal, political, and social competencies, investor and investment competencies, startup management competencies based on the feedback from the consumers of social services.

In the direction of activities of social entrepreneurs, there are more startups focused on the idea of Smart City (popularization of smart technologies for urban residents, the creation of digital services to coordinate people in the areas of healthcare, education, choosing a professional and career path, logistics of movement and accommodation, and other "smart services" for city dwellers). In Russian cities, there are still no options from social entrepreneurs for citizens to assess the "smart decisions" of the authorities—Smarter Together (like the London social project "Smarter London Together" implemented via Trello-board). In Moscow, an example of creating a platform for supporting urban student projects is the Molo.Ko platform [4, 9].

The problems of developing the infrastructure for supporting social start-ups and the problems of institutional traps that social entrepreneurs face in implementing startups were investigated using the method of discourse analysis of the founders of social startups, speaking at the expert sites of the social innovation forum, as well as on the basis of publications and interviews of the founders of social startups in mass media. The additional material for the study was the projects submitted to the competition of social projects in the framework of the Russian Prize "Social Innovations" and in the framework of the Moscow Entrepreneurial Award "Breakthrough of the Year" [3]. Based on the results of the discourse analysis, types of institutional traps were identified and are systematized in three categories: time (users "unpreparedness to use new technologies, problems of changing the value perception of startups, products, and services"), space (undeveloped support infrastructure and insufficient legal norms for implementing startups), politics (ability to manage changes, build communications with key stakeholders, and the possibility of influencing the situation of space-time).

All three factors of institutional traps for social entrepreneurs were proposed to be ranked in relevance to the implementation of startups. An assessment of factors' significance by a priori ranking revealed the significance of the "politics" category (with a concordance coefficient of $W = 0.87$), which is statistically significant and indicates a high degree of agreement between the founders of social startups.

4 Discussion

Thus, an analysis of the study's results revealed that social entrepreneurship is becoming a special force of social policy, which allows developing technological potential and overcoming institutional traps, including the middle-income trap.

The genealogy of the middle-income trap is associated with the advantage of the lagging (catch-up) type of economy, but as the economy reaches the middle income, this advantage is lost as a result of the competitive pressure of modern technologies. The middle-income trap appears as a result of the inability to transform the potential for the realization of technologies into the potential for design, institutional transformations, and sociocultural changes [14]. To overcome institutional traps of this kind, the founders and leaders of social startups must have new types of competencies (competencies for constructing a project in society, its social and organizational design, change management, the ability to determine the functionality of a project, product, and service implemented by a startup, its value chain). The researchers call the middle-income trap "the trap of middle-level innovation" (the trap of potential transformation) [1]. To overcome these kinds of pitfalls, a novice social entrepreneur needs a special kind of competency—constructing product or service functionality and organizational design, accumulating and reflecting trial and error experience. Educational platforms, startup support services, and acceleration programs should be built as sociocultural institutions for developing such competencies as startup management services.

In countries with a high level of innovation [5], the platforms, services, and acceleration programs to support startups are built in the "learning-by-building" model (training during the construction, training based on trial and error reflection). Furthermore, in the countries with an average level of innovation, start-up support programs are built in the learning-by-doing model (minimizing mistakes through training in the practice of successful examples) [8]. Startups grown in the learning-by-building model and their leaders with relevant competencies are more capable of realizing the technological potential in the context of designing transformation management and overcoming institutional traps (including traps of an average level of innovation).

In turn, this leads to increased investor confidence in such startups and their competent leaders. According to Rosstat [10], the investments in social startups have increased in Russia, although three years ago, the investors did not consider investments in socially responsible business as part of their investment strategy.

Social entrepreneurs join the ranks of organizations that are implementing technological innovations and using the commercialization of intellectual property [2].

This indirectly demonstrates a change in the management model of social startups and a change in the competency profiles of social entrepreneurs.

5 Conclusion

The analysis of the management practices of startups of social entrepreneurship, the analysis of the institutional conditions for their support (vesting a legal status), an analysis of changes in platforms and services, and the acceleration programs for startups revealed the urgency of changing startup support models and the transition from the learning-by-doing model to the learning-by-building one. This transition affects the change in the competency profile of the founders/leaders of social startups, as well as their strategies for realizing the technological potential in connection with the ability to construct management of social changes and implement the organizational design of social transformations. The analysis of startups in social entrepreneurship by economic activities revealed an increase in the investment of social startups and an increase in their profitability from the commercialization of intellectual property. The factors of a favorable environment for the development of start-ups in the category of social entrepreneurship, based on the data from the Startup Ecosystem Ranking (space, time, politics), are analyzed. The main factor in the effective management of social startups is the consistent social policy of supporting startups and changing organizational support models: methodological approaches for implementing acceleration programs and managing the competence deficit of startup teams.

The changing policy for the development of social innovations also changes the organizational formats for working with space-time, involving citizens in the processes of creating social innovations: for the first time in Moscow, the annual Forum of Social Innovations of the regions will be held in an open format for public participation—"Moscow—the territory of innovative solutions for breakthrough development." Thus, on the basis of the learning-by-building model, an infrastructure for the innovation system's transformation is created.

References

1. Agenor, P.R.: Caught in the middle? The economics of middle-income traps. J. Econ. Surv **31**(3), 771–791 (2017)
2. Board of the Federal Service for Intellectual Property.: The results of the activities of Rospatent in 2018 and tasks for 2019. Retrieved from https://rupto.ru/content/uploadfiles/otchet_rp_2018.pdf (2018)
3. Breakthrough of the Year: Moscow Entrepreneurial Award.: Retrieved from https://pg.mbm.ru (2019)
4. Forum of Social Innovation of Regions.: Retrieved from https://social-forum.ru (2019)
5. Global Innovation Index.: Retrieved from https://www.globalinnovationindex.org/gii-2017-report (2019)
6. Index of physical volume of investments in fixed assets by types of economic activity.: Retrieved from https://www.gks.ru/free_doc/doc_2018/bul_dr/inv_fakt18.rar (2018)
7. Lee, J.D., Baek, C., Maliphol, S., Yeon, J.I.: Middle innovation trap. Foresight STI Gov. Ance **13**(1), 6–18 (2019)
8. Lee, K.: Capability building and industrial diversification. In: Felipe, J. (ed.) Development and Modern Industrial Policy in Practice: Issues And Country Experience, pp. 70–93. Edward Elgar, Cheltenham, MA (2015)

9. Moscow State Pedagogical University.: A new urban platform for startups has appeared in Moscow. Retrieved from https://www.mgpu.ru/moloko-student-startups/ (2019)
10. Rosstat.: Investments in Russia. 2017: Statistical Digest. Rosstat, Moscow (2017)
11. Russian Federation.: Federal Law "On the Development of Small and Medium Enterprises in the Russian Federation" (March 5, 2019 No. 620203–7). Retrieved from https://duma.gov.ru/news/29953/ (2019)
12. Social Entrepreneur Fellowship.: Official website. Retrieved from https://sapsocialentrepreneurfellowship.splashthat.com (n.d.)
13. Startup Ecosystem Ranking.: The 2015 Global Startup Ecosystem Ranking. Retrieved from https://blog.startupgenome.com/the-2015-global-startup-ecosystem-ranking-is-live/ (2015)
14. Vivarelli, M.: The middle-income trap: A way out based on technological and structural change. Econ. Chang. Restruct. **49**(2–3), 159–193 (2016)

Innovative Motivation as a Factor of Improving the Quality of Human Resources and the Development of Socio-economic Systems

Olga I. Menshikova, Sofya S. Stukanova, and Irina P. Stukanova

Abstract The paper focuses on the impact of innovative motivation as a qualitative characteristic of human resources on solving a large-scale and strategically important task—increasing the growth rate of the Russian economy. A comparative analysis shows a significant gap between Russia and world leaders in terms of GDP per capita. The paper discusses scientific approaches that justify the various ways of modernizing the Russian economy. The authors highlight the main factor of its support—innovative motivation, the main carrier of which is a person. The paper also analyzes dynamics of individual indicators capturing the development of the production sphere, innovative components of the Russian economy, and labor productivity indicators. The analysis shows the need to take into account the human factor and increase the level of innovative motivation. The proposed evaluation methodology will allow creating an informational basis for making managerial decisions at micro and macro levels of socio-economic systems.

Keywords Innovative motivation · Economic growth · Human resource quality

1 Introduction

Developing a country's economy through ensuring its qualitative growth necessitates the search for methods and mechanisms that enhance the development and application of new technologies in production processes, foster the release of innovative products, and increase the competitiveness and efficiency of enterprises.

O. I. Menshikova (✉)
All-Russian Research Institute of Labor of the Ministry of Labor and Social Protection of the Russian Federation, Moscow, Russia
e-mail: Om-g@yandex.ru

S. S. Stukanova · I. P. Stukanova
Cheboksary Institute of Moscow Polytechnic University, Cheboksary, Russia
e-mail: ss.zhuk.ufrf@mail.ru

I. P. Stukanova
e-mail: stukanova_irina@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_2

Today, Russia sets the increase in the growth rate of the economy; consolidation in the five largest economies of the planet is its main task [15]. This task is large-scale and quite ambitious because, over the past decade, the Russian economy has not been able to achieve faster growth rates. Moreover, according to experts, the period from 2008 to 2018 was one of the worst in the last 130 years. Thus, in 2018, GDP per capita in the Russian Federation, according to the International Monetary Fund, amounted to $9264.27 (73rd place in the world ranking), which indicates a significant lag behind world leaders such as Luxembourg ($110,864.07), Switzerland ($80,113.90), and Norway ($73,775.53) [3]. And if in 2008 this indicator was 20% higher than the world average according to purchasing power parities of currencies, then it fell below the world average by 2.6% in 2018 [1].

Recently, experts have been discussing various ways of modernizing the economy and making an economic breakthrough. Some experts are pessimistic in their assessments and say that the modern Russian economy is not capable of a breakthrough, predicting stagnation with the prospect of a dive [1]. Others note the need for systematic [6] catching up [10], modernization, or justification of the advisability to look wider and, therefore, to modernize not only the Russian economy, but the whole society [8].

One should agree with the latter, since the leading role in the implementation of transformations of any type and the implementation of a qualitative leap belongs to the person, their abilities, capabilities, and desire to participate and contribute to the renewal of the economy, to increase the stability of the functioning of socio-economic institutions. From this point of view, the most important factor is ensuring the development of individual enterprises, industries, and the economy as a whole is innovative motivation. Measuring its level and taking into account its dynamics will allow taking timely management measures aimed at achieving sustainable qualitative transformations.

2 Materials and Methods

Innovative motivation characterizes the desire of the economy and society as a whole to carry out modernization through stimulating the development, implementation, and use of innovative ideas, technologies, products to solve strategic problems of the country's development [16]. Obviously, this process involves economic entities of macro-, meso-, micro-, and individual levels, each of which can be characterized by a certain level of development of innovative motivation. Agreeing with the point of view that the microlevel of the economy determines the meso- and macrolevels, although it is influenced by them [7], we believe that in order to ensure sustainable development, the most important task is to revitalize enterprises and increase their innovative motivation. On the other hand, the mutual conditionality of the development of enterprises, the qualitative characteristics of their employees, regions, and the country as a whole determines the need to take into account the factors of macro and individual levels when studying innovative motivation.

The official statistics published by Rosstat (Table 1) indicate the ambiguous influence of the macro-environment on the development of the manufacturing sector and the innovative component of the economy. On the one hand, in the period from 2005 to 2017, there has been a decrease in the total number of enterprises and organizations, which is, rather, a negative factor. On the other hand, the number of organizations engaged in research and development is insignificant but has increased.

At the same time, it should be noted that the motivation for research work is decreasing, as evidenced by a decrease in the number of employees engaged in research and development, the absence of a noticeable increase in patent applications filed, etc.

At the same time, the number of developed advanced technologies has doubled, although not all of them are used in production processes, which is reflected in one of the lowest labor productivities among OECD countries, lower only in Mexico, (Table 2) and inhibits the implementation of process technologies, products, and other innovations.

The given data and factors are not exhaustive in determining the level of innovative motivation. Moreover, some of them need additional specifications in order to identify

Table 1 The dynamics of individual indicators of the development of the manufacturing sector and the innovative component of the Russian economy

Indicator	Year				
	2005	2010	2015	2016	2017
Number of enterprises and organizations (end of year)	4,767,260	4,823,304	5,043,553	4,764,483	4,561,737
Number of organizations performing R&D	3566	3492	4175	4032	3944
Labor forces at the age of 15–72 years, thousand people	73,581	75,478	76,588	76,636	76,109
Number of personnel engaged in research and development, people	813,207	736,540	738,857	722,291	707,887
Number of filed patent applications for inventions and utility models	32,726	40,479	40,672	37,438	32,908
Number of issued patents for inventions and utility models	26,405	31,814	30,950	29,494	29,413
Developed advanced manufacturing technology	637	864	1398	1534	1402
Used advanced manufacturing technologies	140,983	203,330	218,018	232,388	240,054

Source Egorenko [2]

Table 2 Labor productivity in OECD countries and in Russia

Country	Labor productivity	Country	Labor productivity
OECD average	54.8	Austria	72.2
Ireland	99.5	Germany	72.2
Luxembourg	98.5	USA	72
Norway	83.1	Netherlands	71.4
Belgium	76.8	Russia	26.5
Denmark	76.4	Mexico	21.6

GDP per worked hour, 2017, US dollars, at current prices at purchasing power parity
Source Solovieva [11]

the qualitative component of innovative development. Thus, for example, studying not just the dynamics of the number of enterprises and organizations operating in the economy but also determining the proportion of organizations implementing various types of innovation seems to be more significant. Taking into account the human factor in solving the problem involves studying not only the number of workers engaged in research and development but also the ratio of the age groups of these workers, their level of qualification, the formation of a corporate culture aimed at developing creative activity, etc.

The average age of researchers is 47; compared to 2006, in 2016, the proportion of researchers aged 40–49 and 50–59 has significantly decreased (by 5.4 and 10.2, respectively) [4, 5]. However, there is a positive trend in the proportion of researchers with higher education.

The significance and influence of the considered factors on the level of innovative motivation determined the possibility of developing methods for assessing it at the macro and micro levels [13]. So, Formula 1 allows one to evaluate innovative motivation at the macro-level (coefficient of innovative motivation, k_{IMma}), the development of which forms the environment for the intensification of innovative activity, and innovative motivation of enterprises and organizations (k_{IMmi}) (Formula 2).

$$k_{IMma} = A_I \times \frac{N_{\mathrm{R\&D}}}{N_{emp}} \times P_{igTP} \times \frac{N_{gp}}{N_{pa}} \times \frac{E_{R\&D}}{E} \times \frac{N_{at}}{N_{dt}} \times CLR_{rs} \quad (1)$$

A_I is the proportion of organizations implementing innovations of various types in the total number of organizations;
$N_{R\&D}$ is the number of people engaged in research and development (people);
N_{emp} is the number of people employed in the economy (people);
P_{igTP} is the proportion of innovative goods (works, services) in total production;
N_{gp} is the number of granted patents (units/year);
N_{pa} is the number of filed patent applications (units/year);
$E_{R\&D}$ is total expenses for science, research, and development in the budget of the country (₽/year);
E is total budget expenditures for the country (₽/year);

N_{at} is the number of advanced technologies used (units);
N_{dt} is the number of developed advanced technologies (units);
CLR_{rs} is the coefficient of labor replacement of workers in the research sphere (calculated on the basis of the number of researchers under the age of 29 years old replacing the number of researchers aged 60 years and above).

$$k_{IMmi} = \frac{N_{R\&D}}{N_{total}} \times \frac{(PW_{cr} + PW_{com})}{2} \times \frac{N_i}{N_t} \times \frac{N_{pc}}{N_{tp}} \times k_{IMma} \quad (2)$$

where

$N_{R\&D}$ is the number of people engaged in research and development (persons);
N_{total} is the total number of employees (persons);
PW_{cr} is the proportion of workers satisfied with the degree of their creative activity and its implementation in the total number of employees of the enterprise;
PW_{com} is the proportion of employees satisfied with the effectiveness of the enterprise's communication policy (level of "openness" of managers, degree of participation in the management, generation, and participation in the implementation of innovations);
N_i is the number of innovations introduced at the enterprise in the study period (units);
N_t is the number of modern (advanced) technologies used at the enterprise in the study period (units);
N_{pc} is the number of innovative products created by the enterprise during the period under review (units);
N_{tp} is the number of types of products (units); and.
k_{IMma} is the coefficient of the innovative motivation of the socio-economic system of the macro level (for the period under review).

3 Results

The application of the proposed methods made it possible to calculate indicators of the level of innovative motivation at the macro level (in the country) and at the level of individual enterprises. The base of the study was taken by food and processing enterprises, on which a sociological survey was conducted, which allowed for the determination of individual indicators of the level of innovative motivation (for example, the number of employees satisfied with the degree of their creative activity and the effectiveness of the communication policy). The remaining data used when using the proposed methodology were taken from official sources [4, 5, 14] (Table 3).

Table 3 The calculation of the coefficient of innovative motivation of macro and micro levels

Year	Macro level coefficient	Micro level coefficient
2010	0.0012	0.00073
2011	0.0011	0.00066
2012	0.0097	0.00031
2013	0.0012	0.00070
2014	0.0098	0.00088
2015	0.0106	0.00136
2016	0.0125	0.00157

It should be noted that the low level of innovative motivation in enterprises is largely caused by the corresponding value of motivation at the macro level. The enterprises in conditions of high competition and struggling for the consumer are trying to differentiate the offer, build effective CRM systems, and introduce product, marketing, and other innovations [12]. However, the influence of macro-level factors in many respects restrains the pace of the development of enterprises, the most significant of which should be considered a decrease in the population's motivation for research work and, as a result, a lack of appropriate personnel, unbalanced labor market; the need to invest in improving the educational and qualification component of the quality of labor resources [16], economic instability, the associated slowdown in economic growth and underutilization of social and labor potential [9].

4 Discussions

The desire for creative, constructive work, and the presence of deep, relevant knowledge are the key characteristics of the quality of human resources necessary for making an economic breakthrough. The innovative motivation of workers largely determines the possibilities for the development of enterprises, increasing their competitiveness, innovative activity, expanding the possibilities of developing and using advanced technologies, and introducing innovative products into production. Mutual conditionality and the level of development of innovative motivation at the present stage determine the need for a number of measures aimed at the development of socio-economic systems of micro and macro levels: increasing the funding of science and research and stimulating scientific research; increasing the attractiveness of scientific and research professions, the value of knowledge and the prestige of professionalism; and stimulation of creative activity of workers and the introduction of advanced developments in the economic activities of enterprises and organizations.

5 Conclusion

The implementation of qualitative economic growth, ensured by the corresponding development of enterprises and industries, is determined by the level and opportunities for improving the qualitative characteristics of human resources, among which one of the main is innovative motivation. Accounting and analysis of its dynamics allow us to assess the initial state and the potential for the implementation of the economic breakthrough, to identify the constraining factors and the direction of corrective managerial influences.

References

1. Bashkatova, A.: An economic breakthrough can turn into a "dive". *Nezavisimaya Gazeta*. Retrieved from www.ng.ru/economics/2018-03-20/1_7193_nurok.html (2018)
2. Egorenko, S.N. (ed.): Regions of Russia. Socio-economic indicators. Rosstat, Moscow, Russia (2018)
3. Fincan: GDP per capita of the world 2018. Retrieved from www.fincan.ru/articles/51_vvp-nadushu-naselenija-stran-mira-2018/ (n.d.)
4. Gorodnikova, N.V., Gokhberg, L.M., Ditkovsky, M.N., Koncemir, M.N., Kuznetsova, I.A., Lukinova, E.I., Martynova, S.V., et al.: Science indicators—2018: a statistical digest. Higher School of Economics, Moscow, Russia (2018)
5. Gorodnikova, N.V., Gokhberg, L.M., Ditkovsky, K.A., Kuznetsova I.A., Lukinova E.I., Martynova, S.V., Ratay, T.V., et al.: Indicators of innovation: 2017. Statistical Digest. sHigher School of Economics, Moscow, Russia (2018)
6. Kleiner, G.B.: Systemic modernization of the Russian economy. Retrieved from https://kleiner.ru/sistemnaya-modernizatsiya-ekonomiki-rossii/ (2011)
7. Kleiner, G.B.: Systemic modernization of domestic enterprises: theoretical justification, motives, principles. Econ. Reg. **13**(1), 13–24 (2017)
8. Kudrin, A.L.: Ways to modernize the Russian economy. Retrieved from https://cyberleninka.ru/article/v/puti-modernizatsii-rossiyskoy-ekonomiki (2011)
9. Menshikov, O.I.: The formation, development, and use of social and labor potential in conditions of economic instability. Stand. Living Popul. Reg. Russ. **4**(198), 86–96 (2015)
10. Polterovich, V.M.: The institutions of catching up development (to the draft of a new model of Russia's economic development). Econ. Soc. Chang.: Facts, Trends, Forecast. **5**(46), 34–56 (2016)
11. Solovieva, O.: Labor productivity in the Russian Federation is either growing or falling. The authorities, in contrast to the population, "felt" the success of national projects. Retrieved from www.hg.ru/economics/2019-02-14/1-7508_sochi.html (2019)
12. Stukanova, I.P.: Product quality management of enterprises in the marketing system. Bull. Mosc. State Reg. University. (Econ.) **4**, 99–105 (2015)
13. Stukanova, S. S. (2018). Managing the quality of labor in socio-economic systems. (Synopsis of a Thesis of Dissertation of Doctor of Economics). Moscow, Russia: Russian Research Institute of Labor.
14. Surinov, A.E. (ed.): Russian statistical yearbook 2018. Rosstat, Moscow, Russia (2017)
15. TASS: Putin: The pace of economic growth is still insufficient to dramatically improve living standards. Retrieved from https://tass.ru/ekonomika/5845256 (2018)
16. Zhuk, S.S.: Institutional and instrumental aspects of human resource quality management. Dashkov and K, Moscow, Russia (2015)

The Implementation of Internal Corporate Social Responsibility of Entrepreneurial Structures in Innovative HR Management

Varvara Yu. Kulkova

Abstract The practices formed for the development of company personnel in the implementation of corporate social responsibility require scientific generalization. The purpose of the study is to quantify the implementation of internal corporate responsibility as innovative human resources management. In the paper, we use such methods as: rating based on factors grouped in three areas (social responsibility to employees, social responsibility to the surrounding community, and environmental responsibility); the analysis of the dynamics using growth rate indicators calculated in a chain and basic way. The scientific novelty of the study is determined by the obtained results. In the study period, the growth of corporate social responsibility (CSR) in the entrepreneurial structure of the Tatneft Company was established. This indicates that the Tatneft strives to fulfill its obligations to society and maintain the quality of corporate strategies in the field of environmental safety, as well as responsible business. An increase in the CSR rating also indicates that the Tatneft is actively strengthening the image of a socially responsible company, fulfilling social obligations to its own employees, thereby realizing internal corporate responsibility as innovative human resources management. The key limiting factors in the implementation of internal CSR as innovative management of human resources were identified. Growth points, which development should be aimed at improving CSR (corporate volunteering, etc.), were also identified.

Keywords Human capital · Corporate social responsibility · Sustainable development · Entrepreneurship

1 Introduction

Since the UN Conference on the Human Environment held in Stockholm in 1972 and the adoption of the sustainable development paradigm in the 1987 report "Our Common Future" by the International Commission on the Environment and Development,

---

V. Yu. Kulkova (✉)
Kazan State Power Engineering University, Kazan, Russia
e-mail: Kulkova77@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_3

the topic of business social responsibility has become increasingly relevant. The integration of the conceptual foundations of corporate social responsibility (CSR) into business development strategy is a modern trend for foreign and domestic business structures, from large to medium and small enterprises [7]. In addition, in the context of the formation of a social and solidary economy, there is an improvement in the tools for implementing CSR and the expansion of the forms of implementation of social responsibility in business (tangible and intangible social investments) from environmental responsibility to fulfilling social obligations to company staff. It contributes to the development of independent internal forms of corporate responsibility. The practices of the company's personnel development in the implementation of corporate social responsibility incite innovative management of human resources and require scientific generalization.

The aim of the study is a quantitative assessment of the implementation of internal corporate responsibility in innovative human resource management. The object of the study is the PJSC Tatneft. This object was chosen because of the factual information availability o and the fact that corporate social responsibility is the most important principle of the work of PJSC Tatneft. The activities of PJSC Tatneft in this area are systematic in nature and aim to create effective and safe jobs, ensuring social protection of employees and their families, continuous professional development, and a favorable social situation in the regions of activity.

2 Materials and Methods

A theoretical justification of the impact of CSR on staff was started in 1930 in the works of L. Brown. He promoted company managers' accountability and social responsibility to not only owners but also personnel, consumers, and society [6]. In modern conditions, the positioning of corporate social responsibility as a personnel management mechanism is developing in the theory of rational egoism. This mechanism recognizes the need for social programs, which guarantee a favorable social environment for the company's employees and the territories of its activity and allow for its profit stability [6].

In the author's studies, internal CSR (social activity directed at the company's personnel) and external CSR (social activity directed at stakeholders from the external environment of the company) are distinguished [5]. The analysis of the implementation of external CSR in regional cases of large budget-forming entrepreneurial structures was carried out earlier [4].

Methodological approaches to the quantitative assessment of CSR are sufficiently developed (the Triple Bottom Line method, the Balanced Scorecard method, the London Benchmarking Group method, the European Foundation for Quality Management Model for Business Excellence, the Corporate Philanthropy Index, the Social Index-SI, the Dow Jones Sustainability Index, the FTSE4Good Index, and the Domini Social Investment Index (DSI 400)).

Researchers [2] characterized these CSR methods in the context of evaluation criteria and shortcomings. In order to overcome them, the method developed by N. A. Krichevsky and S. V. Goncharov is used [3]. The latter is distinguished by the ease of use and is focused on the most basic indicators of a company that implements the principles of CSR in its activities. Krichevsky's methodology does not contain indicators of the economic activity of the enterprise. However, a group of indicators is provided according to the following groups: a group of indicators of social responsibility to employees (the wage growth rate (R_{wg}), the staff turnover rate (R_{st}), the rate of hired young specialists (R_{ys}), the rate of the growth of employees' educational level (R_{el}), the rate of occupational injuries (R_{oi}), the rate of social expenses per employee, the rate of social spending to net profit), a group of indicators of social responsibility to the surrounding community, a group of indicators of environmental responsibility. As can be seen, the described method allows us to quantify the implementation of internal corporate social responsibility and describe its place in the integrated CSR rating regarding the areas of social responsibility to the surrounding community and environmental responsibility.

At the first stage of the study, within the framework of Krichevsky's methodology for constructing an aggregate CSR rating of a company based on quantitative indicators, we calculated the average quantitative indicator, then adjusted it in accordance with the value of the qualitative indicator (I_q).

At the second stage, according to the results obtained at the previous stage, we analyzed the dynamics using indicators of growth rates ($I_q^{2012/2013}$, $I_q^{2013/2014}$, and $I_q^{2012/2014}$).

3 Results

The corporate social responsibility rating of PJSC Tatneft is presented in Table 1.

As can be seen from the results of the rating, the overall level of social responsibility in PJSC Tatneft is growing in the studied period. The obtained conclusion is verified in the results of the analysis of CSR dynamics (Table 2).

The results of the analysis of the growth rates of CSR quantitative indicators of PJSC Tatneft give grounds for the following characteristics of the dynamics of CSR implementation in quantitative and qualitative indicators:

- The wage growth-rate does not change, relative to the previous period. It indicates the stability of the policy.
- The staff turnover rate decreases compared to previous periods. It characterizes the enterprise management's interest in the safety of personnel.
- The rate of hired young specialists has changed, but not significantly. It acts as a limiting factor in the implementation of internal CSR as an innovative management of human resources.

Table 1 The assessment of CSR level of PJSC Tatneft for 2012–2014

Indicator	Designation	Years		
		2012	2013	2014
Quantitative indicators				
The wage growth rate	R_{wg}	112.3	112.5	112.7
The staff turnover rate (%)	R_{st}	5.5	5	4.7
The rate of hired young specialists (%)	R_{ys}	3.1	3	2.67
The rate of the growth of employees' educational level (%)	R_{el}	18.9	19.0	20
The rate of occupational injuries (%)	R_{oi}	23.5	25.0	30.3
The rate of social expenses per employee (%)	R_{se1}	134.0	134.3	135.3
The rate of social spending to net profit (%)	R_{se2}	0.6	0.7	0.7
The rate of community support cost (%)	R_{cs}	0.7	0.7	0.8
Qualitative indicators				
Collective agreement	I_{ca}	1	1	1
Organizational structures of social policy	I_{os}	1	1	1
Annual social report	I_{sr}	1	1	1
Social research	I_{socr}	1	1	1
Sound business practice	I_{bp}	1	1	1
Qualitative indicator of social responsibility	I_{qsr}	1	1	1
Reference indicator				
Environmental protection cost ratio (%)	R_{epc1}	0.6	0.6	0.6
	R_{epc2}	0.6	0.6	0.6
Total CSR		298.6	300.2	307.2

Source Calculated by the author base on the (Annual Report of PJSC Tatneft [1])

Table 2 The dynamics of CSR implementation in PJSC Tatneft for 2012–2014

Indicator	$I_q^{2012/2013}$ (%)	$I_q^{2013/2014}$ (%)	$I_q^{2012/2014}$ (%)
Wage growth rates	+0.2	+0.2	+0.4
Staff turnover rates	−9.1	−6	−14.5
The rate of hired young specialists (%)	−3.2	−11	−13.9
The rate of the growth of employees' educational level (%)	+0. 5	+5.3	+5
The rate of occupational injuries (%)	+6.4	+21.2	+28.9
The rate of social expenses per employee (%)	+0.3	+0.7	+0.10
The rate of social spending to net profit (%)	+16.6	0	+16.6
The rate of community support cost (%)	0	+14.3	+14.3
The environmental cost rate	0	0	0

Source Compiled by the author base on the (Annual Report of PJSC Tatneft [1])

- The rate of the growth of employees' educational levels is increasing annually for the period presented. The company pays attention to the development of personnel associated with improving the qualifications of employees, stimulating, and creating conditions for efficient and quality work.
- The rate of occupational injuries has increased, but not significantly. However, attention should be paid to maintaining additional health standards and safety conditions.
- The rate of social expenses per employee is increasing annually. It indicates a competent social policy in relation to the employees.
- There was an increase in the company's social expenses relative to net profit in 2013. It remained at the same level in 2014.
- The dynamics of changes in indicators of social responsibility to the surrounding community did not decrease significantly.
- The coefficient of environmental protection costs relative to cost and net profit remains stable. It demonstrates the company's interest in the effective implementation of the program that is aimed at reducing the harmful environmental effects of production activities.

4 Discussion

The results of the study show that, despite the constant increase in the overall level of social responsibility in PJSC Tatneft in the studied period, it is possible to identify the bottlenecks in its social policy. In particular, in the implementation of internal CSR as innovative human resources management, the negative factors are the presence of occupational injuries and the low reception of young professionals.

The positive factors in the implementation of internal CSR as innovative human resources management include stable wages, lower staff turnover, equivalent environmental-protection costs, an increase in social costs to net profit and social expenses per employee, and an increase in the educational level of employees.

5 Conclusion

A quantitative assessment of the corporate social responsibility of PJSC Tatneft shows an increase in CSR in the entrepreneurial structure. It indicates that Tatneft strives to fulfill its obligations to society and maintain the quality of corporate strategies in the field of environmental safety and responsible entrepreneurship. An increase in the CSR rating also indicates that PJSC Tatneft is actively strengthening the image of a socially responsible company, fulfilling social obligations to its own employees, and, thereby, realizing internal corporate responsibility as innovative human resources management.

The verification of the implementation of internal corporate responsibility as an innovative human resources management tool employs identified positive factors. They are stable wages, lower staff turnover, an increase in the educational level of employees, equivalent environmental protection costs, an increase in social costs to net profit, and social expenses per employee. The bottlenecks in the social policy of PJSC Tatneft were identified. The implementation of internal CSR as an innovative management of human resources, the presence of occupational injuries, and the low reception of young specialists are negative factors.

Growth points, development of which should be aimed at improving CSR, are in particular the meager value of the coefficient of the ratio of expenses for community support (R_{cs}). This allows us to conclude that it is necessary to intensify corporate volunteering (volunteering among enterprise employees) in the direction of participation in social support of the local community by including employees in the events of Tatneft charitable foundations.

References

1. Annual Report of PJSC Tatneft. Retrieved from https://tatneft.ru (2012–2014)
2. Grekova, G.I., Kivarina, M.V., Kuzmin, A.V., Rudenko, K.A.: The Interaction of Entrepreneurial Structures, Authorities, and the Population in the System of Social Partnership. Novgorod State, Veliky Novgorod, Russia (2010)
3. Krichevsky, N.A., Goncharov, S.F.: Corporate Social Responsibility. Dashkov and Co, Moscow, Russia (2008)
4. Kulkova, V.Yu.: Corporate social responsibility of large entrepreneurial structures as a determinant strategy for ensuring the sustainability of economic development. Central Russ. Bull. Soc. Sci. **12**(3), 97–107 (2017)
5. Kulkova, V.Yu., Safin, I.Kh.: Implementation of corporate social responsibility in the socio-economic development of the region. Natl. Interests Priorities Secur. **36**(177), 72–80 (2012)
6. Spreckley, F.: Social Audit—A Management Tool for Co-operative Working. Springer, New York, NY (1981)
7. Turkin, S.: The Benefits of Being Good: Make Your Business Socially Responsible. Alpina Business Books, Moscow, Russia (2007)

Safe Anti-Crisis Business Management in an Age of Changes

Ivan D. Matskulyak, Dmitriy I. Matskulyak, and Nemat Z. Nagdaliev

Abstract The purpose of the study is to reveal the essence of safe anti-crisis business management in an era of change, to identify the main components of this multi-aspect process based on modern research methods—collecting, processing and grouping factors, analysis and synthesis, scientific abstraction and generalization, the unity of logical and historical methods. As a result, the objectivity of changes is revealed, in which conditions modern domestic businesses are managed. In particular, the authors argue that they are based on the action of the economic laws of labor changes, changes in production, and changes in the economy. The forms of manifestation of each of them are presented. The need for the transition of society from a mixed market, a mixed economy to a managed market, a controlled economy is considered. It is concluded that both the managed market and the controlled economy require regulatory support, strengthening the economic thinking of personnel, a radical adjustment of the teaching of teaching science in a managed mixed economy at all levels, and solving the agrarian question. The content of the work carries a scientific increment. A particular burden belongs to the concretization of understanding the safe anti-crisis business management, the clustering of this process based on the strategic replacement of the sectoral approach by the territorial-sectoral, using the example of created innovative territorial clusters.

Keywords Secure crisis management of a business · Change of labor · Change of production · Change of the economy · Territorial and branch management · Clustering · Innovative territorial cluster

I. D. Matskulyak (✉)
State University of Management, Moscow, Russia
e-mail: mid48@mail.ru

D. I. Matskulyak
Yukon Line LLC, Moscow, Russia
e-mail: midio@mail.ru

N. Z. Nagdaliev
Ekonomika Fund, Moscow, Russia
e-mail: n_n_zed@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_4

1 Introduction

The relevance of the chosen topic is based on the need to further increase the effectiveness of the main link between the market economy and socio-economic development in the country. This is especially important in an era of change, including eliminating the consequences of the global financial and economic crisis, which impose higher requirements on market participants. The specifics of economic reforms in Russia, the lack of sufficient experience of enterprises in such conditions, and the highest level of managerial staff and financial management led to a significant overdue debt of enterprises for payments to the budget and extrabudgetary funds. Their long insolvency (1) often requires radically breakthrough approaches in such structures.

2 Materials and Methods

The aim of the paper is to reveal the essence of safe anti-crisis business management in an era of change and to identify the main components of this multi-aspect process. The tasks arising from it include substantiate the objectivity of change, identify important areas of crisis management in business at a safe level, and concretize business management in a clustering economy.

The object of the study identifies domestic unprofitable and highly efficient enterprises. The subject identifies socio-economic relations between market entities for overcoming the crisis and pre-crisis states of a number of them.

At the same time, methods that have been widely used in economic research in recent years are applied. They include collecting, processing, and grouping factors; analysis and synthesis; scientific abstraction and generalization; the unity of logical and historical methods, etc. These approaches made it possible to focus the theoretical and methodological foundations of the proposed study on at least three aspects covering the results and discussions.

2.1 The Objectivity of Change

Paying attention to the objectivity of change, let us point out not just the fact of the transition to a market economy from the system preceding it; this is obvious. Moreover, the relevant practice is very multi-faceted—from restoring the rights of diversity of ownership and management to minimizing the role of the state in the economy. Moreover, this process was also carried out, unequally, during different periods. The 90s are one thing, and the current time is quite another. There is no doubt that this trend will continue to manifest itself even more intensively.

The latter circumstance is confirmed in many phenomena. Thus, along with the traditional economy, the so-called innovative economy is widely spreading in practice. There are also intellectual, information, digital, credit, mobilization, and breakthrough economies. At the same time, it is generally accepted that there is a social economy. There also exist the global and regional economy, the knowledge economy, the economy of missed opportunities, etc. Each of them, in addition to the fundamental principles, has its own unique properties, qualities, and features, including corresponding goals, objectives, capabilities, functions, principles, and results.

The above and many other innovations are based on objective social laws, namely: the law of labor change (1), the law of production change (2), and the law of economic change (3). The forms of their manifestation are presented in Table 1.

These laws are in dialectic unity, interconnected and interacting with other constantly repeating trends of the modern mode of production. At the same time, the focus of emerging economic relations, including the totality of relations of safe anti-crisis business management, objectively meets the requirements, first of all, of the basic economic law. Their potential seems to take into account the influence of the

Table 1 The forms of manifestation of the laws of labor change, production and economy

The forms of manifestation	The laws of change of …		
	Labor	Production	Economics
1	Changes in the content of professions or specialties	Changes in the content of technology, organization of social production	Changes in the content of economic conditions for the implementation of design, production, distribution, exchange, and consumption
2	Disappearance of the former and the emergence of new professions and specialties	Disappearance of the former and the emergence of new technologies; organization of social production	Disappearance of the former and the emergence of updated economic conditions for the implementation of design, production, distribution, exchange, and consumption
3	Labor release and movement	The formation of new technological structures and the corresponding organization of social production	Spread of new economic conditions for the implementation of design, production, distribution, exchange, and consumption

laws of the planned development of the national economy; cost; time-saving; steady growth of labor productivity; distribution of labor, etc.

In other words, the process of change embraces the whole society; it spreads independently of the desire, will, and consciousness of a person. The latter is designed to reckon with this process, taking into account the relevant requirements in its management.

2.2 Safe Anti-Crisis Business Management

The creation of a new, safe environment for a business to function currently necessitates transitioning society from a mixed market and a mixed economy to a *managed market and a managed market economy* with the corresponding attributes (5). In this regard, society faces at least four tasks [2]:

1. *Regulatory support for solving the indicated problem.* The application of the concept of a managed market is an alternative to a mixed market and a theoretical justification of the feasibility and necessity of strengthening *the role of the state in planning, organizing, regulating, motivating, and monitoring* the functioning of the production and market sphere, as well as its security. The main thing is the primacy in the implementation of each of the listed components of the managed market. Therefore, the controlled market economy of the country should belong to the state.
2. *Strengthening the economic thinking of leading cadres.* In order to take into account the requirements of economic laws in managing a mixed economy, its modernization in accordance with the 2020 strategy, and the security improvement, it is important to achieve from its subjects, and, above all, senior personnel, a more constructive approach and an understanding of the discussed socio-economic processes. Hence, in our opinion, there is a need for the *widespread development of modern economic thinking and economic and other managerial personnel*.
3. *The solution to the agrarian question.* This is a key aspect of ensuring the growth of the country's economy and its security, especially during the transition to a controlled market, a managed mixed economy, and, therefore, to business management in an era of change. This link, "can pull out the entire chain," i.e., having succeeded in agriculture, we can count on a breakthrough in the entire economy.
4. *A radical restructuring of the teaching of the science of managing a mixed economy in higher education.* Despite repeated attempts in recent decades to reform domestic education, including its economic and managerial sphere, it is not possible to achieve the desired results. The solution to this problem must be combined with economic practice in the *same interest*. Then, the formation of a managed mixed economy will occur not only on the basis of the market, but also on the knowledge accumulated by mankind!

The higher school is called upon to teach how to concentrate *the existing world experience in diverse areas of economic and managerial activity and apply it when creating an effective economic system* at different levels. A methodological approach, such as a peculiar criterion for teaching economics and management sciences, could be an innovative perception of the market that is mixed and managed on the basis of a deep understanding of economic laws, their systems, their forms of action, and their manifestation and takes into account requirements in social production.

2.3 Business Management in a Cluster

Safe anti-crisis business management is a set of socio-economic relations between the subjects of social production in ordering the organization of diagnostics, prevention, neutralization, and overcoming of crisis phenomena and their causes at all levels of the economy (6). Its essence consists of the development and implementation of the most rational, innovative option for the withdrawal of enterprises from a crisis state or its prevention. This process is characterized, as practice confirms, by a contradictory variety that can be represented by several groups (7).

The cluster approach in safe anti-crisis business management refers to such a system of economic and managerial relations within insolvent enterprises, between them and other participants of the territorial cluster, and between all of them and the outside world, which forms the necessary socio-economic mechanism that serves as the basis for overcoming of the state crisis (bankruptcy), increasing profitability, and increasing the effectiveness of the use of productive forces of the corresponding region.

Nowadays, the importance of *innovation clusters* (joint *projects of companies, scientific, and educational centers, development institutes, and local authorities* on creating an innovative cluster network in this territory) is growing dramatically [5].

A key role in guiding the cluster economy is played by innovative systems, which are the basis for the formation of innovative territorial clusters (ITCs)—important vectors in increasing the clustering of domestic business management. This new organizational and cluster order, designed for the growth of innovative initiatives, transforms the existing traditional sectoral business management into territorial-sectoral and all its subsystems toward dynamic self-development based on synergy effects.

A business clustering strategy (BSC) can be safe and successful if all of its key factors are taken into account (expansion of cooperation relations between business entities; building value chains; development of import-substituting competencies and industries; increasing investment attractiveness and competitiveness of enterprises (companies)).

BSC radically changes the organizational structure of production. On its basis, ITCs, which are currently being considered as a necessary way of economic growth and increasing its pace, are being formed. Therefore, the problem sounds quite simple: taking into account the experience of developed countries, *it is necessary to* *build a cluster business economy* that integrates leading research and educational organizations, high-tech industries, development institutions, and state (municipal) authorities in a certain territory.

Cluster business management is a new institutional mechanism, that is, the formalization of a set of techniques and methods that facilitate the use of new approaches. Such management covers the totality of actions of business, government, educational, and research institutions, as well as other structures to create favorable conditions for economic development of the business environment. It unites the efforts of all participants that stimulate the emergence of cluster networks as safe tools for increasing national competitiveness up to its transition to an innovative type of breakthrough growth.

The advantages of ITC are as follows: innovation is the main factor of clusters; a certain territory, a specific subject of the federation, is the foundation of the cluster; industry focus is a cluster specialization.

The establishment of *anti-crisis business management* in the era of changes directly in the clustering system and, therefore, on *management within the ITC* is of primary importance for economic growth. We believe that on this basis, the country could achieve breakthrough economic growth.

An important area of clustering could be cooperation between R&D, business, development institutions, and local authorities in order to bring bankrupt enterprises to the level of sustainable anti-crisis production and related management. This would make crisis enterprises profitable, sustainable in development, and, at the same time, solve a number of other important issues.

The foregoing allows us to formulate a number of final conclusions. Firstly, the goal set in this work and the tasks corresponding to it are solved. Secondly, the fact that the most important area of safe anti-crisis business management in an era of change is the clustering of the domestic economy is confirmed. Finally, the third conclusion is formulated in the fact that in the fundamental increase in the level of the economic thinking of all participants in these processes, from ordinary workers to business executives of the highest rank, including government and political figures.

Notes

1. It is enough to refer to the data of the Federal State Statistics Service (Rosstat) published on March 26, 2019. According to it, the share of unprofitable organizations in Russia in January 2019 increased by 0.7% in annual terms and reached 35.8% [7].
2. The nature of the "large-scale industry," as noted by K. Marx, who first formulated the essence of this law, "determines the change of labor, the movement of functions, the comprehensive mobility of the worker … large-scale industry itself makes the recognition of the labor change a matter of life and death" [1]. Modern machinery is not the final form of the production process. Its technical basis is completely revolutionary, in contrast to the conservatism of all previous methods of production preceding it. This is clearly seen in practice, when new

machines, electrical and chemical processes, and other methods are introduced into the production process of a large machine industry. It constantly improves the technical basis of production and, at the same time, the functions of workers and social combinations of the labor process [3].

3. "The social law of the change of production reflects a stable, constantly renewed relationship between participants in social production regarding its development taking place in the conditions of improving the production base of the modern national economy and associated with the formation of new organizational and technological structures that apply them to multilaterally developed aggregate workers, for whom various social functions are successive more productive ways of creating consumer oimostey, own livelihoods" [4].
4. "The social law of economic change is a stable, constantly renewed relationship between members of society regarding national economic development, including the branches of material production and the non-productive sphere, aimed at satisfying personal and social needs on the basis of its new organization meeting the changes in production and labor" [4].
5. By a mixed market, it is customary to understand the type of market that has developed in recent decades, in which multistructure is formed. At the same time, there prevail various spheres of activity aimed at commercial profit-making by any means. In a mixed market, value relationships are distorted. Therefore, financial instruments dominate the economy, not the primacy of production; virtual financial capital, not exchange processes; and deformed prices of goods, not a monetary expression of their value. In fact, these processes have reached planetary proportions. The profit of financial agents of different segments of the mixed market is formed, among other things, due to financial rent and opportunistic speculative incomes, or even the shadow economy, which they assign. The basic beginning of such processes in a mixed market is the financial economy "in which the global financial system dominates" [6]. "*The managed market is, first of all, the market where the requirements of economic laws, their systems in the course of conducting the national economy, including the application of value relations applicable to the sphere of exchange (mixed market) are taken into account*". The controlled market cannot withstand other stages of the passage of resources when creating a product or providing a service—design, production, distribution, and consumption. They are called to correlate among themselves. In other words, a mixed market can and should function in a mixed economy. Consequently,*a managed market can and is called to work as part of a managed economy*. In this case, it, as well as the managed economy as a whole, will be based on the theory of labor value, cleared of non-typical layers, including, among other things, commercial interests and dictates of banks. The tax system in such conditions involves the transfer of rental income from the market profits of raw material enterprises to the state budget with their subsequent redistribution to social needs, including the needs of people with disabilities, orphanages, nursing homes, and other poor people. This allows expanding consumer demand and economic growth, and its security [2].

6. “Crisis management of the economy” as a scientific concept is applied in a wide and narrow sense. In the first case, it represents the systemic management of an economic entity at a particular economic level, from the point of view of countering the crisis; in the second—as a system of organizational and managerial measures and actions regarding the economy of a particular enterprise, which is in a state of crisis or is constantly reducing the effectiveness of its functioning. This is usually expressed in insolvency, which, in case of its protracted insurmountable nature, is neutralized through the bankruptcy procedure. For the crisis management of business in the narrow sense, the identification of its financial insolvency is of great importance. The official establishment of this fact is fixed on a legislative basis. It is considered, usually in court, by the Federal Office for Insolvency of the State Property Committee. In this case, it is important to keep in mind the state anti-crisis management of the economy (SACME). Apparently, it can be perceived as a phenomenon reflecting relations at the macro level that arise during the organizational, economic, and legal impact of the state when protecting enterprises from crisis situations, preventing bankruptcy, or terminating their further functioning. SACME is a regulatory phenomenon, i.e., it is quantified. It proceeds from an analysis of the situation, the most specific and clear setting of goals, and the development of tools that can transform crisis situations in the direction of solving assigned tasks.
7. “A cluster is a device of a territorial and sectoral partnership, united by an innovative program for introducing advanced breakthrough production management technologies in order to increase the competitiveness of its participants” [5].

References

1. Marx, K., Engels, F.: A Collection of Works, vol. 2, USSR: State Publishing House of Political Literature, Moscow (1958). (Искал ссылку сам, слишком мало входных данных…)
2. Matskulyak, D.I., Matskulyak, I.D.: A Change in Political and Economic Relations and Security. State University of Management, Moscow, Russia (2016)
3. Matskulyak, I.D.: Economics: Scientific Essays, 2nd edn. Publishing House of the Russian Academy of Public Administration, Moscow, Russia (2005)
4. Matskulyak, I.D.: Change of economy: essence, manifestation, use. Actual socio-economic problems of Russia. In: Proceeding from the Scientific Session of the Economics Section of the Russian Academy of Sciences (22–23 Sept 2016), Moscow, Russia, Pero (2016)
5. Matskulyak, I. D.: Crisis management of the economy at the meso and micro levels—a cluster approach. Problems of economic management at the meso and micro levels: a collection of articles from the Department of Economic Theory and World Economy. In: Moky, M.S., (ed.) State University of Management, Moscow, Russia
6. Osipov, Y.M.: Time “FIN”. In: Business Philosophy: Almanac of the Center for Social Sciences and the Faculty of Economics of the Moscow State University, vol. 5, pp. 141–144 (2011)
7. Regnum.: The share of unprofitable organizations in Russia reached 35.8%. Retrieved from https://regnum.ru/news/economy/2599080.html (2019)

The Problems with Information Support of Strategic Management

Gyulnara A. Adamova, Marina D. Khabib, and Marina Y. Teplyakova

Abstract Currently, most successful companies have moved from short-term planning to consistent strategic business management. The scope of strategic decisions is much wider than in those taken within the framework of operational management, therefore, the approaches to accounting and analytical support of management are changing. The management accounting system should be built on the basis of the study of the global goals of the company, evaluating its strengths and weaknesses, as well as market conditions of activity. Its main purpose is to create an information basis for the distribution of tasks and resources between the structural units of an economic entity in such a way as to ensure the optimal ratio between capital invested in business and profit. The aim of the study is to consider the main problems of providing information for strategic management in an ever-changing market environment and to develop proposals and recommendations that allow us to determine conceptual approaches to the formation of an array of data necessary for making managerial decisions for the long term. The main problems that management companies face when making strategic decisions are highlighted. The authors discuss the possibility of using a number of accounting and analytical tools for information management in a dynamic market environment. A form of internal reporting is proposed to assess the current market position of a company in order to predict its competitive position in the market for a particular product. A form of a diagnostic card for providing an opportunity to assess the prospects of launching a new product is proposed as well.

Keywords Strategic management · Strategic management accounting · Accounting and analytical management support · Cost management · Management decisions

G. A. Adamova · M. D. Khabib · M. Y. Teplyakova (✉)
State University of Management, Moscow, Russia
e-mail: teplyakova-marina@yandex.ru

G. A. Adamova
e-mail: gul-adamova@yandex.ru

M. D. Khabib
e-mail: marina-khabib@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_5

1 Introduction

The last few decades clearly show that long-term success in business is achieved only by those companies whose management not only controls current activities but also consistently implements strategic goals. In this regard, there is a problem with quality information support based on new approaches to the management of an economic entity in a rapidly changing market environment.

What requirements should be met by the information with which it is possible to effectively manage the company in the long term? First of all, it is important to understand what strategic goals the organization is facing at the moment. The information generated in the framework of management accounting, on the one hand, should be systemic in nature, and, on the other hand, should be correlated with the chosen direction of development. The value of the information presented will be determined by the consequences of its use; therefore, the data should not only be collected but also carefully processed and aggregated with a sufficient degree of reliability and timeliness.

At the same time, the traditional tools used in operational management accounting, such as analysis, planning, and control, should qualitatively acquire new features in the information support of strategic management [1]. In particular, if the current control managers usually only have information about the state of the internal environment, the achieved level of profitability, use the assessment of deviations of actual indicators from budgeted, etc., then, from the point of view of strategic decision-making, the situation on the market of goods and resources, and possible prospects of its changes should be analyzed in the first place. Moreover, an important role in the strategic success of the company belongs to the effective management of costs of both its own and attracted resources, which also requires the organization of appropriate accounting and analytical support.

2 Materials and Methods

The theoretical and methodological basis of this study was the work of leading Russian and foreign scholars on the problems of organizing accounting and analytical support for strategic management, materials of scientific conferences, seminars, and periodicals.

The research used: the method of scientific abstractions, analysis, synthesis, induction, and deduction, as well as a systematic approach. An analysis was made of the most common problems faced by companies engaged in the manufacturing of products with a relatively short (from 3 to 7 years) life cycle. Based on the analysis and generalization of the obtained results, recommendations and proposals for the preparation of accounting information were developed in order to successfully predict the market position of the organization, as well as to assess the prospects for launching individual products in production.

3 Results

Accounting and analytical support for strategic management should be based on indicators reflecting the dynamics of changes in the company's position in the market in relation to its main competitors. A set of indicators should be developed, which values can serve as an indicator that the used market strategy needs adjustments. In the interest of making strategic management decisions, management reporting, in our opinion, should include information obtained as a result of a comparative analysis of sales volumes and set prices of competitors, as well as the extent of the advertising campaigns conducted by them. An example is the recommended report form for assessing the market position of a company for an individual product (Table 1).

The indicators presented in the report must be studied in dynamics over a number of periods. By monitoring changes in the market shares of competitors for the main products supplied by the company to the market, we can get a real picture of how the positions of its most important rivals in the market are developing. "The inclusion of market share data in management accounting reports helps to make it more meaningful strategically" [4]. At the same time, sources of information can be both public and informal channels.

When considering alternatives to expand the manufacturing of products, or, conversely, to curtail it, it is necessary to be guided by the data on additional or disposable costs associated with such decisions. The indicators of the cost and profitability of

Table 1 Recommended report form for assessing the market position of a company by product X in comparison with its main competitors

Indicators	Our company	Company A	Company B	Company C
Sales volume, th. units	30.5	42.0	39.4	25.8
Specific weight%	22.15	30.50	28.61	18.74
Revenues, ₽ th	76,555	104,160	99,288	64,629
Specific gravity, %	22.34	30.40	28.98	18.86
Average price, ₽/unit	2510	2480	2520	2505
Relative comparison value, %	100.0	98.8	100.4	99.8
Variable cost, ₽/unit	1850	1700	1800	1690
Relative value of the comparison, %	100.0	91.9	97.3	91.4
Profit margin, ₽/unit	660	780	720	815
Relative value of comparison, %	100.0	118.2	109.1	123.5
Rate of margin profit in revenue, %	26.3	31.4	28.6	32.5
The cost of advertising the product, ₽ th	500.0	900.0	650.0	400.0

Source Compiled by the authors

products calculated in a classical way cannot answer the question of how feasible such solutions will be since they are based on the inclusion in the cost of a significant proportion of costs not directly related to production volumes, and, therefore, are not relevant in this case. In order to prepare decisions of this kind, it is necessary to correctly assess the consequences of changes in all costs, including those that are usually included in the cost of production but will also be present when the manufacturing of the product is completely minimized. We are talking about using the concept of relevant income and expenses, that is, income and expenses whose level of will vary depending on the decisions made. The use of this concept is especially important when management decisions can have long-term consequences. The determination of the horizon of these consequences, both positive and negative, is also an important component of strategic management and, accordingly, accounting. Table 2 shows the proposed form of the diagnostic card for conducting a comparative analysis of the conditions for launching a new product in case of a need for an alternative choice.

Table 2 The proposed form of a diagnostic card for a comparative assessment of the launch of new products in case of a need for an alternative choice

Indicator name	Product X	Product Y
Market capacity, units		
Potential share of the company, units		
Average price, ₽/unit		
Potential revenue, ₽		
Production cost, ₽/unit		
Fixed costs:		
In absolute terms, ₽/unit		
Share of production costs, %		
Variable Costs:		
In absolute terms, ₽/unit		
Share of production costs, %		
The amount of fixed costs that can be eliminated in case of a phasing out of production in the future:		
In absolute terms, ₽		
Share of production costs, %		
The value of fixed costs, with the possibility of transfer to variables due to the partial acquisition of resources on the side:		
In absolute terms, ₽		
Share of production costs, %		
Marginal profit A (for a given level of variable costs)		
Margin profit B (if fixed costs are reduced by translating into variables)		

4 Discussion

The market environment is dynamic; as a result, each company operates under the pressure of potential threats from the arrival of new competitors, the introduction of new products, or changes in consumer preferences. Thus, long-term success can only be achieved by implementing a series of consistent competitive strategies that are adjusted to changing circumstances. The traditional type of management accounting used by most companies, as a rule, provides information in the form of a comparison of planned and actual performance indicators in the context of units, market segments, and products. Moreover, in most cases, accounting staff and managers are not ready to revise budget indicators even when circumstances indicate a change in the parameters of the external environment, which means automatic obsolescence of the information presented in approved plans. As noted by C. Ward, "an assessment of managerial activity based on outdated and incorrect indicators of standard costs is a manifestation of excessive enthusiasm for in-house comparative analysis, which is widely used in traditional managerial accounting" [10].

Unfortunately, such data is not enough to solve strategic management tasks. In our opinion, the replacement of static budgets with flexible ones will not resolve the situation because the traditional forms of internal reporting often simply cannot correctly identify problems associated with external circumstances. One of the key tasks facing strategic management accounting is to identify the need to change the applied competitive strategy. The indicators should necessarily include the results of a comparative analysis of environmental factors: "Only the use of market-oriented comparative accounting and analysis can reliably explain the relative current changes in sales income, profits, and cash flows, as well as their possible consequences" [10].

Currently, the operational monitoring of market conditions is difficult due to the lack of proper research infrastructure. However, surveys conducted by various organizations can be used. In particular, data published on a quarterly basis by the largest rating agency, Expert RA, on various market segments, can be of undoubted interest, as well as indicators from the annual reports of large companies, which, in accordance with applicable law, are subject to disclosure in public sources. These sources contain information on the volume and structure of sales of specific types of goods and services, revenue, incurred expenses, and profit margins. In order to assess the market environment, small and medium-sized enterprises may use as sources of information the results of special surveys conducted at the level of regions and sectors of the economy, as well as trade statistics at the regional level in a quarterly format.

When organizing management accounting, one should clearly understand which of the possible market strategies the company adheres to. Depending on this, it will be clear what information and what context is primarily needed. For example, for conservative companies that prefer to work in stable industries with mass production and constant demand for products with rarely changing characteristics, the most important thing is to ensure low costs and accurate compliance with all established standards. These companies become leaders by improving the quality of their products and customer service. It should be recognized that "even with maintaining a stable assortment, competition in the market requires constant attention to maintaining competitive production costs" [7]. The cost analysis from the point of view of their relationship with the volume of activity and the determination of the optimal structure of variables and fixed costs is of great strategic importance [2]. It will be especially relevant when the company can use external resources instead of internal; that is, it chooses from options for procurement or its own production. Own production is usually associated with a large share of overhead as part of costs; thus, a critical point of activity will be reached only with a high level of income, which significantly increases the financial risks of the company in case of a sharp decline in demand for products or when demand is significantly below the forecast. The acquisition of external resources increases the share of variable costs, thereby reducing possible losses in cases of unforeseen situations. On the other hand, the possible benefits in the case of successful forecasts and growth in demand for products will also be small.

However, when speaking about overhead costs and their place in achieving a critical volume of activity, one must also take into account how they are included in the cost of manufactured products. In modern production, the share of direct costs is steadily decreasing, and thus, the chosen method of distributing indirect costs will play a fundamental role in deciding whether to launch certain products on the market: distorting their real cost can lead to an incorrectly-planned production structure and sales [5]. Thus, "the quality of the information provided by strategic management accounting for the analysis of the profitability of various product groups is largely determined by the applied system of accounting and distribution of costs" [9]. In the calculation of such cost factors, it is important to use factors that will reflect the real relationship of indirect costs with products. The traditionally-used methods of cost estimation are mostly not suitable for the preparation of information for the strategic management of a company.

For the purposes of strategic cost management, it seems appropriate to initially analyze the composition of production costs in order to identify the most expensive resources. The primary attention of managers should be paid to reducing these costs. Cost reduction is possible in two ways: (1) through a reduction in resource consumption and (2) through increasing the efficiency of its use. In this case, a large role is played by the collection and analysis of information about all the costs of the company. Moreover, if the use of traditional management accounting systems is directly related to the current control of the production company's activities and is aimed at ensuring compliance between planned and actual costs by complying with previously established standards, then strategic management accounting should, in our opinion, provide information management. With the help of information management, one can not only eliminate the occurrence of unplanned expenses but also achieve a reduction in the achieved level of costs. For this purpose, it is advisable to consider the costs both during the period of active manufacturing of the product and at the stages preceding it—that is, associated with the development and design. In addition, the analysis is subject to costs determined by the promotion of the product on the market and after-sales customer service. Currently, the largest Western companies are increasingly building their strategic planning based on the concept of the value chain proposed by M. Porter in 1985. Its use allows the identification of the main competitive advantages of the company in the market. The costs of the company should not exceed the product value it creates. An analysis of the cost chain carried out in the organization allows one to see at what stages the cost of the product increases and at what cost consumption does not entail its growth. At the same time, the company will have competitive advantages, which costs will be lower than those of competitors when creating similar products.

In accordance with this concept, the company's activities can be divided into primary and secondary. The first includes all business processes related to the production of a product, its promotion, and after-sales service. They form the value of the product for the consumer; that is, they participate in the creation of value. Supporting activities are aimed at maintaining the efficiency of the main processes through the improvement of production technologies, labor-management methods, as well as improving the infrastructure of the company. It is necessary but does not directly participate in the creation of the product.

The main activity includes 5 blocks, each of which is associated with the next and the previous, thus forming a value chain and, at the same time, a chain of costs for its implementation: (1) the acquisition and storage of raw materials; (2) production, including processing of raw materials, packaging of the finished product, as well as quality control; (3) distribution of the product, including its storage and transfer to customers; (4) marketing and sales—advertising and promotion of products, selection, and development of sales channels; (5) service, including all activities designed to preserve the value of the product transferred to the buyer, including after-sales service, training, and repair. Each element of the cost chain can become a strong or weak link, depending on what costs it is associated with: if the costs of carrying out activities are lower than those of competitors, and its results are comparable in level, then we can speak of strategic advantage. The whole set of activities appears as a system of interconnected stages, where each subsequent link is a consumer of the product of the previous link, who is invited to evaluate the quality of the product supplied to him and, thus, it is possible to identify weak links, defining "opportunities for improving activities along the entire cost chain" [4].

The target costing—allowing implementations of marketing functions simultaneously with design, resulting in a product that meets the expectations of consumers—has direct connection with the concept of Porter's value [6]. It is also based on functional management, which considers the entire business as a set of interrelated activities. In order to design a product with the desired functional characteristics and the desired level of profitability, the work of a whole team of engineers, marketers, production managers, purchasing agents, etc. should be involved. Each of the participants of the project monitors characteristics of a particular product in accordance with established competitive consumer properties. At the same time, the desire for targeted costs should not reduce the degree of customer satisfaction, nor does the provision of specified quality parameters provide grounds for laying in the product properties that are not mandatory, that is, those that the client is not willing to pay. In accordance with the concept of functional management, each of the activities carried out by the company causes costs, but not each of them creates a cost for which the consumer is willing to pay. Strategic cost management requires the maintenance of activities that guarantees consumers the satisfaction of their requests related to purchased products and, at the same time, reduces the cost of activities that do not create value [8].

In general, we can conclude that the tools of strategic management accounting need constant and continuous development and improvement [3].

5 Conclusion

Decisions made in accordance with the strategic goals of the company involve a high level of risk and may have long-term consequences. In accordance with this, it is necessary to form a system of qualitatively new information support, which allows not only to justify the management decisions made, but also with a high degree of probability to calculate their consequences.

As a result of the study, the requirements for accounting and analytical support for strategic management were identified, the need was justified for the use of indicators that not only characterize the internal environment of the company, but also the dynamics of its market position relative to its main competitors, the share of marginal profit in revenue, etc. The given recommended reporting form for individual products allows us to generate information in order to make managerial decisions on changing the assortment policy of the company, the volume of manufactured products, investing in promotional events, etc.

Most of the costs of an industrial enterprise, as well as its losses, lies in the organization of the production process. Therefore, for successful cost management, it is necessary to understand what errors in the organization of production can lead to serious losses on the part of the company. It is not enough to simply compare costs with their normative values; it is necessary to understand which costs create value for the customer and which are additional and can be eliminated without compromising quality. Special attention should be paid to the efficiency of consumption of the most expensive resources. It is important, on the one hand, to establish the optimal ratio between variable and fixed costs in order to ensure the sustainability of the company in the face of a sharp decline or increase in demand for the product while, on the other hand, to ensure that costs are reasonably included in the cost based on establishing a functional relationship between products and the resources consumed in their production. The paper presents a form of diagnostic map developed by the authors for a comparative assessment of the launch of new products into production. Its use allows us to predict the possible consequences of launching a new product with a relatively short life cycle.

References

1. Adamova, G. A.: Management accounting from the perspective of strategic management. Universum. Econ. Jurisprud. Electron Sci. J. **3**, 6–12 (2014). Retrieved from https://7universum.com/ru/economy/archive/item/1063.
2. Adamova, G.A.: Organization of management accounting and cost control. Manage. Account. **4**, 3–10 (2019)
3. Babkina, O.: The tools of strategic management accounting to accounting and analytical support of the enterprise. Transbaikal State Univ. J. **25**(3), 84–95 (2019)
4. Drury, K.: Strategic management accounting. In: Management Accounting for Business Decisions, pp. 567–591. UNITI-DANA, Moscow, Russia (2012)
5. Kaverina, O. D.: Allocation and de-allocation of costs. In: Management accounting, p. 125. URAIT, Moscow, Russia (2019)
6. Konovalova, E.M., Manukovskiy, R.I., Titova, E.A.: Topical problems of calculating the cost of services using the methods "Target costing" and "Kaizen costing." Social-Econ. Phenom. Process. **12**(6), 148–158 (2017)
7. Melnik, M.V.: The role of accounting and analytical functions to maintain the sustainable development of the organization. Innov. Dev. Econ. **4**(21), 33–41 (2014)
8. Shirinov, A.S.: Formation of the modern strategic management cycle and its estimated figures. Econ. Manage. **1**(147), 91–96 (2018)
9. Ushanov, I.G.: Strategic management accounting as an information basis for business analysis. Baltic J. Humanit. **2**(7), 85–88 (2014)
10. Ward, K. Profitability of market segments: a look at the problem. In: Strategic management accounting, pp. 81–112. Olympus-Business, Moscow, Russia (2002)

The Prospects for Using the Target Costing Concept in Domestic Enterprises

Marina I. Samogorodskaya, Irina A. Bejnar, and Tatiana S. Narolina

Abstract The paper focuses on the main features of the Target Costing concept, its differences from the traditional cost accounting system. Also, the authors discuss both advantages and disadvantages with respect to practical applications. The authors state that in current business conditions, characterized by increased competition, increased integration activity, and the digitalization of the economy, only enterprises susceptible to innovation can function effectively. In this regard, the use of the Target Costing methodology, which allows managing costs at all stages of the product life cycle, in authors' opinion, is mandatory for enterprises seeking to expand their market positions.

Keywords Cost management · Cost accounting · Target cost · Target price · Target profit

1 Introduction

In the conditions of modern business, characterized by constant toughening of competition between manufacturers, the primary strategies for competitive advantage and, accordingly, successful business are "cost leadership," "product differentiation strategy," "niche strategy," and "quality priority strategy." For a long period, these strategies brought significant profits to companies. However, technological progress makes adjustments to prevailing traditions and rules. The needs of people are increasing; the market is becoming more and more volatile, new production technologies are appearing, and the cycle of creating and mastering new products is significantly reduced.

M. I. Samogorodskaya · I. A. Bejnar · T. S. Narolina (✉)
Voronezh State Technical University, Voronezh, Russia
e-mail: narolina@inbox.ru

M. I. Samogorodskaya
e-mail: marta17@yandex.ru

I. A. Bejnar
e-mail: beinar@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_6

In this regard, there is a need to apply new modern approaches to the management of Russian enterprises that ensure economic efficiency in the creation and production of innovative products, for example, cost management methods.

2 Materials and Method

The usual practice of economic activity at domestic enterprises in manufacturing industries involves the following mechanism for the application of accounting for production costs: accounting for current costs during the production process; calculation of actual cost; pricing with a priority condition for covering total costs; and ensuring a sufficient level of profit.

The traditional approach to the regulation of costs for the creation of innovative products is based on a standard algorithm:

1. the formulation of technical and functional requirements for the product being developed (stage of the technical specifications—TS);
2. the research and development (R&D) and the design engineering of a new product;
3. the development of technical processes and determination of the need for all types of resources (process-layout preparation—PLP);
4. the determination of potential costs of resources and identification of sources of support (organizational preparation of production—OPP [2]),
5. the calculation of the cost of new products.

Further, two options are considered: (a) if the cost of producing a new product is acceptable for the enterprise, the development and serial production processes are launched; (b) if the production cost is unacceptable, then the necessary changes to the design of the product or the manufacturing process are made (in this case, during serial production, the periodic monitoring of the level of production costs is carried out [10, 11]).

Thus, the main distinguishing feature of the cost planning method at most Russian enterprises is the accounting of possible resource costs (as well as production, administrative and managerial, and commercial overheads), determined by the characteristics of the technologies used. As a result, the so-called “market price” of products is established based on the estimated cost taking into account acceptable profit. This price is not a market price, as the market does not set it, but it was imposed by the manufacturer.

The main disadvantage of this approach is that product developers are puzzled by the problems of reducing costs after research work, design, and technological preparation of production are carried out. Making adjustments to the already made developments is quite a difficult task from a technical point of view, requiring, among other things, additional financial investments.

3 Results

It is of particular interest to analyze the leading management accounting systems used in world practice for various types of economic activity [7, 9] (Table 1).

As part of the research carried out by the Department of Engineering Economics of the Voronezh State Technical University, the analysis of the applied cost accounting systems in various sectors of the economy was made [3], which made it possible to distinguish between two methods according to the joint criterion: Target Costing and Kaizen Costing (Table 2).

According to the results of studies [3, 4, 9], it seems that the Japanese (Toyota Corporation) Target Costing concept becomes the most effective alternative to the normative cost accounting method used in the post-Soviet space in modern realities (the only one allowing to adjust costs from the design stage).

The Target Costing system is a holistic concept of target cost management aimed at comprehensive, complex, and multi-faceted support of a corporate strategy for reducing total costs; the implementation of the planning function of innovative production; preventive control of production costs; and final calculation of target costs in accordance with market realities [12].

The system is based on the idea that manufacturers of new products should focus on the established level of market prices for similar products and plan the price of their products depending on this level.

Therefore, the developer and manufacturer aim to create products that provide the company, under specific prevailing conditions, the desired level of profit by determining the target cost. The value of the named cost should include all costs in the implementation of all stages of the innovation process: the development, creation, and market implementation of the product [6].

A qualitative difference between the Target Costing concept and the methods of cost accounting used in domestic practice is the non-standard—inverse—interdependence of the basic categories: cost, price, and profit. The application of criteria for the formation of costs is carried out in two stages: (1) market requirements orient the manufacturer to the value of the expected price, and (2) formed prices determine the acceptable level of costs.

A prerequisite for improving the technical characteristics and expanding the implemented functions of the product is complying with consumers' demands and the level of solvency of customers. Therefore, the main task of manufacturers and marketers is to determine not the cost of manufacturing a new product at a particular enterprise but its value in the specific market conditions. Thus, unlike the standard procedure, the objective function—costing—is based on determining a pair of leading indicators.

1. Target price is the point at which products should be sold in the planned volume. According to the original methodology of target costing, the specialists should be guided by the following criteria:

Table 1 The advantages and disadvantages of cost management methods

Method essence	Advantages	Disadvantages
Direct Costing: the elimination of fixed overhead costs from the prime cost (accounting as losses)	• Independence of profit from the amount of fixed overhead costs • The reduction in the complexity of costing (overhead) • The ability to reasonably calculate innovation prices • The possibility of optimizing the production program	• The impossibility of unequivocal differentiation of costs by category • Insufficient accounting for fixed costs • The impact of changes in the cost of previously manufactured products on the accuracy of the financial result • The ambiguous dependence of the profitability of technologically complex projects on investments
Standard Costing: determines reasonable consumption rates for each type of cost	• The necessary information base for analysis and cost control is formed • The minimization of accounting work • The preliminary provision of managers with information on production costs	• Cannot be used for non-recurring costs • Strict dependences on the quality of the regulatory framework • The lack of rationing of specific expenses
Activity-Based Costing: determines the total cost of a set of business processes	• Increases the reasonableness of attribution of overhead costs to specific products • The relationship of information processes with the processes of cost formation	• The need for additional costs for amendments to the accounting system and information support
Target Costing: sets the target cost based on a given price and profit margin	• The orientation of production to the market • The ability to form costs at the design stage	• The need for extra time to reduce costs • The need for additional investment • Limited technical capabilities to reduce costs
Kaizen Costing: the focus on continuous comprehensive cost reduction, not limited to a certain amount	• The ability to continually reduce costs and maintain them at the achieved level	• The need for the additional motivation of employees and the presence of a supportive corporate culture

Source [4, 9]

Table 2 Expert evaluation of cost management methods

Evaluation criterion	Weight, b	Standard costing		Direct costing		Activity-based costing		Target costing		Kaizen costing	
		Rating, G	G · b	Rating, G	G · b	Rating, G	G · b	Rating, G	G · b	Rating, G	G · b
Consumer orientation	0.2	2	0.4	2	0.4	3	0.6	5	1.0	5	1.0
Ability to adjust costs at all stages of the life cycle	0.15	1	0.15	1	0.15	3	0.45	5	0.75	4	0.6
Staff motivation	0.1	2	0.2	2	0.2	2	0.2	5	0.5	5	0.5
Impact on business results	0.2	2	0.4	3	0.6	4	0.8	5	1.0	5	1.0
Simplicity in using	0.15	4	0.6	5	0.75	3	0.45	2	0.3	2	0.3
Compliance with the Russian accounting system	0.2	3	0.6	1	0.2	4	0.8	4	0.8	4	0.8
Total			2.35		2.3		3.3		4.35		4.2

   (a) the customer requirements for the technical characteristics and range of functionality of the new product;
   (b) the willingness of consumers to pay for a particular set of necessary characteristics, properties, and functions of a new product at an acceptable price;
   (c) the characteristics of competing products offered by other companies in the industry market;
   (d) the allocation of relative (target) market share for a new product [1].

2. Target profit is designed to ensure the economic feasibility of production. Setting the size of the target profit has its characteristics:

   (a) it is necessary to take into account the interconnection of long-term development strategy and short-term marketing goals (sales volume, range, the market position of products);
   (b) it is necessary to accept prospects of demand for the developed production and a relative share of the market as priority criteria;
   (c) in practice, the company should compare the indicators of return on assets (return on sales) with similar industry averages [13].

The conducted research shows that in the countries with developed economies, the concept of target costing is applied mainly at the enterprises, which release a wide range of products in small series that is characteristic for branches of electronics, mechanical engineering, instrument-making, etc. [2, 8]. When implementing the concept, interconnected joint efforts of developers, managers, economists, and marketers are necessary. In different industries, the method may have different significance at different stages of the innovation process (Fig. 1).

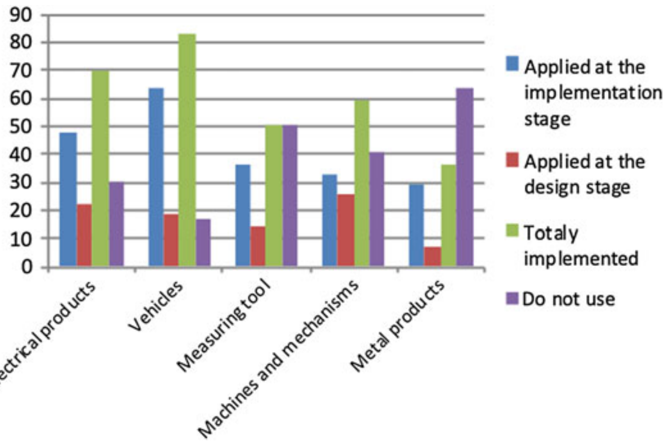

Fig. 1 The degree of implementation of target costing at different stages of the innovation process. *Source* [12]

4 Discussion

The practice of using the selected method reveals a number of its undoubted advantages, somehow:

- the possibility of combining the processes of reducing costs for the production and sale of products with accounting procedures and meeting the needs of customers;
- the possibility of transition to strategic planning and regulation of the processes of formation of costs and profits of the enterprise;
- the expansion of the scope of effective cost control in high-tech areas of production and services, where conventional methods do not work or do not work effectively;
- the simplicity and consistency of integration into the traditional system of accounting methods of accounting and the general financial statements of the enterprise;
- the ability to adjust the process of product design, following the needs of customers, by evaluating the costs of the formation of each product function (in combination with a functional-cost analysis);
- the reduction of the time for product development by limiting the number of alternatives to R&D and design engineering to certain price limits;
- the formation of personnel motivation a priori oriented to market requirements.

Certain limitations of the Target Costing concept are also debatable:

- the method cannot be used from time to time, only as necessary, but should be introduced into the daily practice of functioning of the enterprise's business processes;
- the application of this concept requires a global change in the enterprise management system;
- the achievement of an appropriate level of performance during the product development process is a prerequisite for achieving the target cost level;
- the subjectivity of estimates of consumer expectations, which are the basis for the calculation of both target costs and, ultimately, the target price [13].

The disadvantages mentioned above of the Target Costing method are often noted by researchers as the main obstacles to its implementation in domestic conditions. The analysis of the application of relevant methods of management accounting conducted by the authors on the basis of Russian enterprises in industrial sectors [3–5] made it possible to identify a number of priority problems that may impede the successful implementation of Target Costing in the domestic business:

1. A lack of sufficient staff motivation and clear goal-setting necessary for team interaction.
2. The difficulty of communication interconnections between departments of different levels.
3. Low organizational (corporate) culture.
4. A lack of managerial professionalism.

5. The mismatch between the real goals of the organization and those of senior management.
6. An additional increase in the timing of new product development (due to the appearance of numerous iterations in the design process).
7. Technological, organizational, and/or psychological unpreparedness of the leadership to stop unproductive research and development.
8. The possible explicit and implicit opposition of personnel in the case of directive implementation of the system.
9. The mutually exclusive goals of individual departments (e.g., design and marketing services for general and line-by-line cost reduction).

A careful analysis of the advantages and disadvantages of the studied method allows us to note that the main difficulties in implementing the Target Costing system at domestic enterprises are differentiated in two directions: a lack of organizational training and a low level of production management.

In other words, insufficiently competent management is still the primary reason complicating the potential implementation of a promising accounting system in Russian realities.

5 Conclusion

It is challenging to live in an era of change. It is much easier to travel the path of least resistance. Pricing mechanisms, widely used by domestic enterprises since the time of the command and administrative management system, are simple and easy to use but focused exclusively on the interests of producers. The problems of quality of products and their competitiveness at cost pricing are relegated to the background. It seems that in current business conditions, characterized by increased competition, increased integration activity, and the digitalization of the economy, only enterprises susceptible to innovation can function effectively. Moreover, at present, innovative processes affect not only the technology of manufacturing products, but also aspects of the economy, organization, and production management. In this regard, the use of the Target Costing methodology, which allows managing costs at all stages of the product life cycle, in our opinion, is mandatory for enterprises seeking to expand their market positions.

References

1. Ansari, S., Bell, J., Cypher, J., Dears, P., Dutton, J., Ferguson, M., et al.: Target Costing: The Next Frontier in Strategic Cost Management. McGraw-Hill, New York, NY (1997)
2. Beinar, I.A.: The main directions for reducing the cost of ensuring information security. Inf. Secur. **12**(2), 297–300 (2009)

3. Beinar, I.A.: The methods for assessing the appropriateness of the costs of ensuring an information security system. Competitiveness Innov. Financ. **2**, 44–48 (2015)
4. Demenkova, T.Yu.: The genesis of standard-costing, target-costing, and just-in-time methods as a basis for improving the cost management system. Molodoy Uchenyy **23**, 43–45 (2017)
5. Ermakova, N.V.: Methods of stimulating cost reduction: theoretical and practical aspects. Tauride Sci. Rev. **2**, 156–158. Retrieved from https://elibrary.ru/download/95980050.pdf (2015)
6. Kerimov, V.E.: Target-costing as a tool for determining the target cost. Finance Theor. Pract. **4**, 70–77 (2007)
7. Kuvshinov, M.S.: The analysis of the conformity of management methods to relevant management tasks. Int. Acc. **23**, 14–23 (2014)
8. Lisitsin, V.G., Zozulya, D.M.: Strategic cost management concepts. Sci. Educ. Econ. Econ. Entrepreneurship Law Adm. **5**(48), 26–32 (2014)
9. Poltavskaya, V.Yu., Lukashova, O.A.: Topical problems of production costs management. Molodoy Uchenyy **11**(1), 45–48 (2016)
10. Samogorodskaya, M.I.: Economic instruments of quality management processes. Bull. Voronezh State Tech. Univ. **7**(11–3), 90–94 (2011)
11. Samogorodskaya, M.I.: Economic Aspects of a Quality Management System. Voronezh State Technical University, Voronezh, Russia (2014)
12. Sarzhevskaya, V.V., Peretyatko, E.S.: Comparative characteristics of methods for calculating the cost of finished products: abc-costing and target-costing. New Sci. Curr. Status Dev. Paths **12**(1), 183–187 (2016)
13. Voronova, E.Yu.: The method of target-costing cost calculation. Retrieved from https://afdanalyse.ru/publ/operacionnyj_analiz/analiz_sebestoimosti/metod_target_kosting_kalkulirovanija_sebestoimosti/35-1-0-306 (n.d.)

Monitoring of Stability of the Enterprise with a Long Production Cycle

Artur D. Bobryshev, Mariya V. Chekadanova, and Marina G. Vitushkina

Abstract The paper focuses on the technique of monitoring the stability of enterprises with a long production cycle working in branches of shipbuilding, aircraft industry, and heavy mechanical engineering. The specifics of these enterprises consist of the impossibility of obtaining a reasonable opinion on a condition of their stability by traditional methods owing to the complexity of the applied technology, the high cost of products, and a large number of contractors. Therefore, unlike the acting practice, it is offered to carry out monitoring of the stability in two steps. The first step is to identify the problem zones in traditional areas characterizing the sustainability of the activity. In the second step, if unsatisfactory estimates in any area are detected, the analysis of their reasons by a research of a business model of the enterprise is carried out. The use of the recommended monitoring mechanism allows the analyzed company to make informed decisions regarding the reasons for the change in the stability, as well as to develop specific management decisions, focusing on the indicators for evaluating the components of the business model.

Keywords Stability monitoring · Long production cycle · Business model · Value

A. D. Bobryshev (✉)
All-Russian Research Institute "Center", Moscow, Russia
e-mail: 3646410@mail.ru

M. V. Chekadanova
JSC "RPC "Istok" named after Shokin", Fryazino, Russia
e-mail: mvchekadanova@istokmw.ru

M. G. Vitushkina
Moscow Information and Technological University—The Moscow Architecture and Construction Institute, Moscow, Russia
e-mail: vit_marina@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_7

1 Introduction

The task of ensuring sustainable development is central to enterprises of various industries, legal forms, and forms of ownership. How it is implemented depends on the right choice of managerial decisions in such areas as marketing, logistics, production, relations with suppliers and consumers, product quality, and others. Information for making such decisions is provided by stability monitoring, which is understood as the systematic implementation of the control function, which consists of analyzing the compliance of the stability parameters with given values in order to make managerial decisions aimed at eliminating the identified inconsistencies. Despite the developed scientific apparatus for monitoring and assessing the sustainability of enterprises [1–5], there are practically no recommendations in the literature regarding the features of carrying out these procedures at enterprises with a long production (technological) cycle. Meanwhile, the specificity of such enterprises does not allow them to be limited only to the monitoring approaches that are recommended in the scientific literature. In this case, it is necessary to have a more in-depth study of the qualitative factors that cause changes in the parameters of the characteristics of stability, based on the analysis of the elements of the enterprise's business model.

2 Materials and Methods

The paper was written on the basis of a preemptive analysis of materials from the enterprises of the shipbuilding industry [7–12], with the use of data from other industries with a long production cycle. The study used methods of statistical analysis, mathematical statistics, and business modeling.

3 Results

The study of the practice of a large number of industrial enterprises[1] has shown that the characteristic features of a sustainable enterprise can be displayed in the form of the diagram shown in Fig. 1.

The recommended procedure for monitoring the sustainability of enterprises with a long production cycle includes the actions shown in Fig. 2. Each characteristic of stability is associated with the estimated indicators of group "A" (Table 1). The

[1](JSC Production Association "Sevmash", JSC "Admiralty Shipyards", JSC Shipreparing Center "Zvyozdochka"; PJSC Shipyard "Severnaya Verf"; JSC "Zelenodolsk Plant named after A. M. Gorky"; PJSC "Amur Shipbuilding Plant"; PJSC "Krasnoye Sormovo Shipyard"; JSC "Far Eastern Shipyard "Star""; JSC "Sredne-Nevsky Shipyard"; JSC "Baltic Shipyard"; PJSC "KAMAZ", PJSC "NLMK"; JSC "Kalashnikov Concern", JSC "Rosnergoatom" and a number of enterprises in other industries).

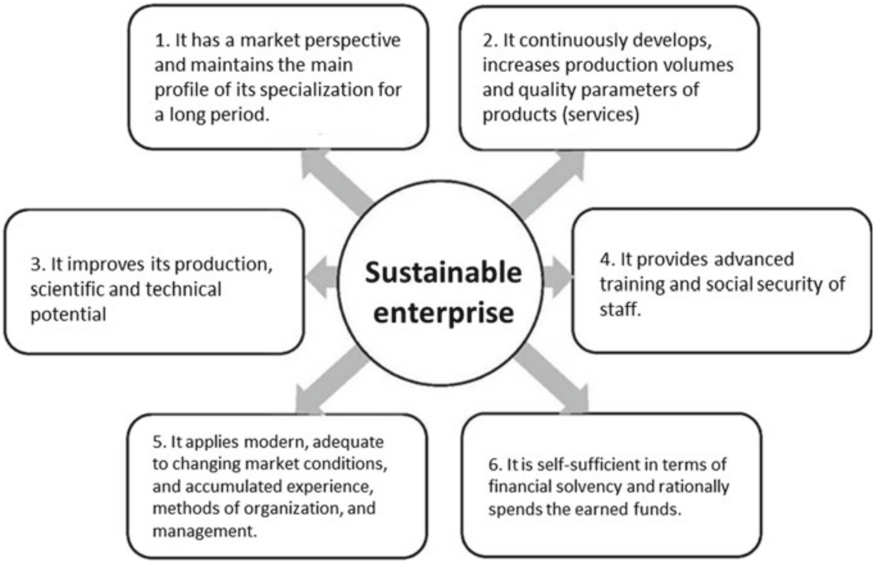

Fig. 1 The characteristics of a sustainable enterprise. *Source* Compiled by the authors

sources of information for their calculation are the data obtained on the basis of factory analytics, accounting, and statistical reporting (both the enterprise and state statistics).

The calculation of the indicators is carried out in three groups of products: manufactured under the state defense order (SDO), through military-technical cooperation (MTC), and civilian products. The calculation results are shown in Table 2.

The initial analysis of estimated sustainability indicators, in comparison with planned indicators, is carried out on the basis of processing the table information. The visual result of such an analysis is the petal diagrams, reflecting the correspondence of planned actual indicators and the ratio of actual indicators with their industry average values (standards).

It should be remembered that industry average indicators are always far from the perfect role model and do not always indicate true landmarks that one needs to strive for. Simultaneously, a comparison with these indicators demonstrates an assessment of an enterprise's state of stability in its familiar environment, which is fundamentally important for enterprises with a long production cycle.

To understand the reasons for the identified trends in sustainability indicators at the minimum level, allowing to formulate an expedient specific management decision, in the next step of the monitoring procedure, a factor analysis (interpretation) of changes in the estimated indicators, based on the decomposition of sustainability characteristics into elements of the enterprise's business model, is carried out. This stage, in turn, is divided into two interrelated parts. The first comes down to establishing the reasons for changing the enterprise's stability parameters, related to the

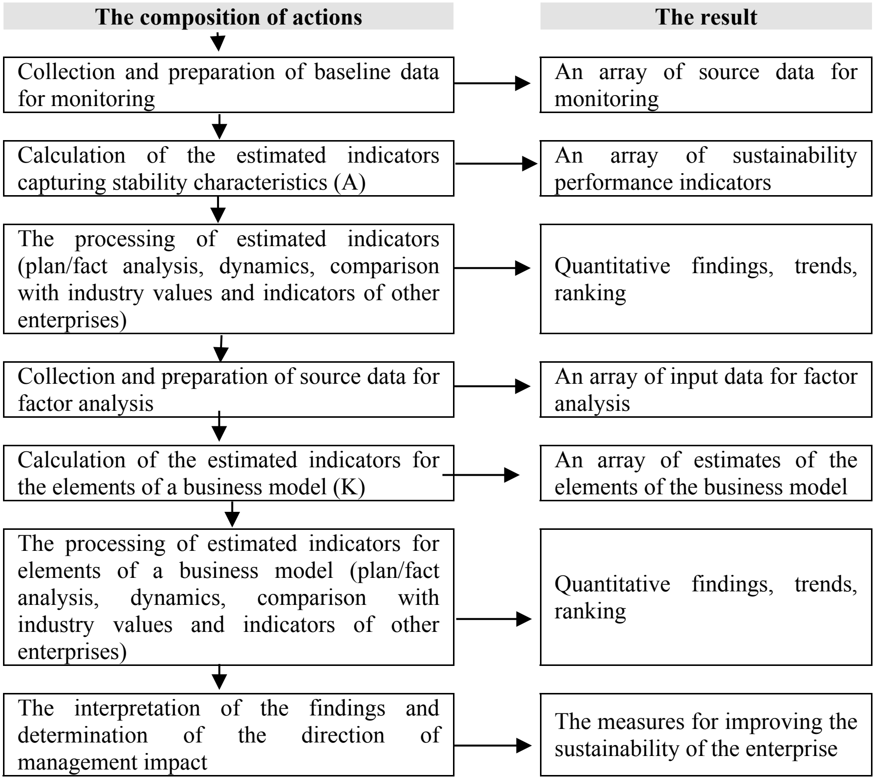

Fig. 2 The algorithm for monitoring the stability of enterprises with a long production cycle. *Source* Compiled by the authors

results of its work (the external contour of the business model) [6]. The logic of this analysis is shown in Table 3.

The second part includes an analysis of the reasons for changing the stability parameters of the enterprise, which characterize the internal organization of the enterprise, ensuring the achievement of the desired level of performance parameters (the internal contour of the business model).

The final stage of the monitoring procedure is to set tasks for the current and long-term correction of the identified influence factors. They include creating excellence in factors of production and value proposition; multi-level consumer segmentation, including individual requests; ensuring that the production and resource base of the enterprise conforms to the task of satisfying individual consumer requests; the formation of a unique product offering; and others.

Table 1 The estimated indicators of stability characteristics (group "A")

Characteristics of sustainability	Cipher	Name of indicator
1. The presence of a market perspective in the chosen field of specialization	A_1	Market share
2. Continuous development, increasing production volumes, and quality parameters of products (services)	A_2	The growth rate of sales volumes
3. The improvement of the production, scientific, and technical potential	A_3	The proportion of R&D costs in the volume of sold products
	A_4	The proportion of costs of technological innovation in the volume of sold products
4. Professional development and social protection of personnel	A_5	The coefficient of stability of the number of engineers and highly skilled workers
5. Application of modern methods of organization and management	A_6	The share of the central production units involved in the implementation of modern principles of organization of production, labor, and management
6. Financial viability and rational spending of earned funds	A_7	The ratio of own and borrowed funds
	A_8	The share of accounts payable on time

Source Compiled by the authors

4 Discussion

The difference between the authors' position on the sustainability monitoring procedure and other recommendations in this area is the assertion that controlling only the quantitative parameters of the sustainability of enterprises with a long production cycle is hardly enough because of the high degree of uncertainty of the results of the activities of these enterprises. On this basis, it is impossible to obtain comprehensive information to assess the situation and make informed corrective decisions. Therefore, the main recommended monitoring procedure is to conduct a factor analysis (interpretation) of changes in indicators based on the decomposition of stability characteristics by elements of the business model of the enterprise.

5 Conclusion

The proposed methodological approach to monitoring the sustainability of enterprises with a long production cycle can significantly increase the objectivity of managerial decisions that will ensure their dynamic development through the use of the apparatus for assessing elements of the business model of enterprise. The decomposition of stability characteristics to the level of categories and indicators that reveal the features of the organizational structure of the enterprise creates a reliable basis

Table 2 Initial data for monitoring stability for the ___ quarter of 20__ (conditional example) (in fractions of a unit)

Code and name of indicator	Pan	Fact	Deviation (co. 3—co. 2)	Industry average value, standard	Deviation (co. 3—co. 5)
1	2	3	4	5	6
A_1 Market share	0.7	0.6	−0.1	0.8	−0.2
A_2 A growth rate of sales volumes	0.07	0.07	0	0.08	−0.1
A_3 A proportion of R&D costs in the volume of sold products	0.2	0.25	+0.05	0.25	0
A_4 A proportion of costs of technological innovation in the volume of sold products	0.08	0.07	−0.01	0.12	-0.05
A_5 A coefficient of stability of the number of engineers and highly skilled workers	0.9	0.91	+0.01	0.9	+0.01
A_6 A share of the main production units involved in the implementation of modern principles of organization of production, labor, and management	0.4	0.35	−0.05	0.2	+0.15
A_7 A ratio of own and borrowed funds	0.9	0.95	+0.05	0.85	+0.1
A_8 A share of accounts payable on time	0.8	0.8	0	1	−0.2

Source Calculated by the authors

Table 3 The logic of establishing the reasons for changing the parameters of the external stability of the enterprise

Sustainability characteristics	Assessment indicators	Elements of a business model	Evaluation indicators
1. The presence of a market perspective in the chosen field of specialization	Market share—$\mathbf{A_1}$	(1) Consumer segments	A share of consumer-oriented products in the total volume of enterprise products—$\mathbf{K_1}$
		(2) Core values	A ratio of the number of products (or the main structural elements of products) for which there were no complaints, to the total number of products (elements)—$\mathbf{K_2}$
2. Continuous development, increasing production volumes, and quality parameters of products (services)	The growth rate of sales volumes—$\mathbf{A_2}$	(3) Channels of value delivery	A share of repeated contracts with the customer in the total number of enterprise contracts—$\mathbf{K_3}$
		(4) Customer relationships	

Source Calculated by the authors

for understanding the causes of the processes occurring in it and justifying actions aimed at improving the stability of the work.

Acknowledgments The authors would like to express their gratitude to A. A. Medvedev, Ph. D., for his valuable recommendations that formed the basis of the paper.

References

1. Avdonin, B.N., Batkovsky, A.M., Mingaliev, K.N., Batkovsky, M.A.: Development of tools for assessing the financial stability of enterprises of the military-industrial complex. Financ. Anal.: Probl. Solut. **10**(196), 2–13 (2014)
2. Barilenko, V.I.: Information and Analytical Support for the Sustainable Development of Economic Entities. RUSAINS, Moscow, Russia (2015)
3. Bazarova, L.A.: The Management of Sustainable Development of the Company. ASV, Moscow, Russia (2007)
4. Bobryshev, A.D., Tumin, V.M., Tarabrin, K.M, Bubenok, E.A., Zenkina, E.V., Iradionov V.I. Panova, E.S. Tarabrin, M.B. Tarabrin, F.M. et al.: Business Models in Managing Sustainable Enterprises. INFRA-M, Moscow, Russia (2018)
5. Bobylev, S.N.: Sustainable Development: Methodology and Measurement Techniques: Study Guide. Economics, Moscow, Russia (2011)
6. Chekadanova, M.V.: The Studies of Ways for Ensuring the Innovative Development of High-Tech Industries of the Electronic Industry. MEDPRAKTIKA-M, Moscow, Russia (2018)
7. JSC “Admiralty Shipyards”: Annual Report for 2017. Retrieved from https://admship.ru/about/disclosure/?year=2018 (2017)
8. JSC “Sredne-Nevsky Shipyard”: Annual Report for 2018. Retrieved from https://www.e-disclosure.ru/portal/files.aspx?id=17491&type=2 (2018)
9. JSC “Zelenodolsk Plant named after A.M. Gorky”: Annual Report for 2016. Retrieved from https://www.e-disclosure.ru/portal/files.aspx?id=14422&type=2 (2017)
10. JSC “Zelenodolsk Plant named after A.M. Gorky”: Annual Report for 2017. Retrieved from https://www.e-disclosure.ru/portal/files.aspx?id=14422&type=2 (2018)
11. JSC Production Association “Sevmash”: Annual Report for 2017. Retrieved from https://www.e-disclosure.ru/portal/files.aspx?id=13354&type=2 (2018)
12. United Shipbuilding Corporation: Annual Report for 2017. Retrieved from https://www.aoosk.ru/upload/docs/GO_2017/interactive_version/index.html#/ (2018)

Dealing Operations as a Means of Improving the Efficiency of the Financial Management of a Production Company

Nataliya S. Plaskova, Natalya A. Prodanova, and Konstantin Y. Reshetov

Abstract In modern conditions of business management, the issues of the efficient use of financial resources are of particular importance, ensuring the constant solvency of production enterprises. For this purpose, it becomes necessary to organize specialized functional units-treasuries in the management structure of vertically integrated companies. One of the tasks that such divisions solve is the operational control, the centralized accumulation of temporarily free funds from enterprises, branches, and divisions that are part of the holding. These funds are further used either for instant repayment of urgent obligations or placed in short-term financial assets that generate income. Based on a critical study of classical approaches to the organization of operational cash management at production enterprises, the directions of reorganization of the cash flow management system for increasing the profitability of the financial activities of the company are proposed. The paper shows the key features of financial resources management in a vertically integrated production company using dealing operations. An original method of assessing the effectiveness of cash flow management for attracting and temporary placement of free cash assets is proposed. The authors also focus on the functioning of the financial service in the management structure of a manufacturing company and the algorithm for evaluating the effectiveness of short-term transactions that contribute to generating additional income and minimizing financial risks.

Keywords Financial management · Vertically integrated production company · Cash flows · Effectiveness of dealing operations

---

N. S. Plaskova (✉) · N. A. Prodanova
Plekhanov Russian University of Economics, Moscow, Russia
e-mail: plask55@mail.ru

N. A. Prodanova
e-mail: prodanova-00@mail.ru

K. Y. Reshetov
National Institute of Business, Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
e-mail: konstantvip@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_8

1 Introduction

One of the features of the financial management of the production activities of industrial enterprises with a sufficiently long operating cycle is the need for the accumulation of significant volumes of both owned and borrowed funds as well as their rational use during the production process, the duration of which is determined by its subject. One particular challenge is the management of long-term financial resources in various forms, which requires the development of appropriate policies for their reasonable use at all stages of the life cycle. The seasonality of commodity and product markets is also a factor in the imbalance of cash flows within the year, which can lead to a shortage of funds in one time period and to a relatively excessive accumulation of free money supply in contrast to other types of assets that do not generate economic benefits. To this end, during periods of accumulation of cash, the organization can use various financial instruments to avoid the depreciation of temporarily free cash assets. This problem can be quite efficiently solved using the mechanism of treasury management of the cash flows of a vertically integrated company. Dealing with operations, which are a reliable lever for maintaining an adequate liquidity level and a tool for minimizing financial risks, can become one of the effective financial instruments [2].

The purpose of the study is to develop a methodology for assessing the effectiveness of dealing with the operations of a vertically integrated production company based on improving the organizational structure of the treasury.

The research objectives are analyzing the features of managing financial flows of vertically integrated production companies and the organization of work of corporate treasuries, substantiating directions for increasing the efficiency of cash flows in manufacturing companies with a long operating cycle and developing a technique for assessing the effectiveness of dealing operations.

2 Materials and Methods

The scientific and practical publications of Russian and foreign experts on the organization of the system for treasury management for cash assets are studied. In the research process, general scientific methods were used: analysis and synthesis, systematization, statistical generalization to substantiate theoretical principles, and practical recommendations aimed at improving the financial flow management system of a vertically integrated production company that is using dealing operations.

3 Results

The rational organization of the management system of a large vertically integrated production company allows the effective use of the entire range of resources, the most important component of which is financial resources. One of the features of financial management in enterprises that are part of the manufacturing industry with a long period of the operating cycle is the uneven flow and expenditure of funds raised from various sources (companies' own funds, borrowed funds of financial and non-financial organizations, loans and borrowings, budgetary and extra-budgetary funds received on either a returnable or irrevocable basis, foreign investors' funds, etc.).

A significant part of the production sphere of the real sector of the economy operates in Russia in the form of large associations, including various enterprises that perform the relevant functions and stages of work. A relatively common form of managing the manufacturing business is the so-called vertically integrated holding, one of the tasks of which is to manage financial flows through the treasury system, which may include the following organization options:

- delegation of each holding company to independently carry out its treasury operations;
- centralized management of financial flows by the parent company;
- the creation of a specialized financial company in the holding structure to manage exclusively financial flows;
- transfer of financial management functions to a third-party outsourcing service company.

This organizational problem is solved from the position of profitability for the business in general with mandatory consideration of all potential risks. As a rule, international corporations retain a certain degree of decentralization of treasury operations, giving their foreign branches a certain autonomy. At the same time, the functions of managing significant cash positions, as well as interest and currency risks, are implemented in the initial stages, and, in the subsequent stages, cash and liquidity management are implemented [3].

Strictly centralized treasury service of the production holding includes the initial and all subsequent procedures for processing incoming and outgoing payments in a single center, which may also manage receivables, payables, and payroll, and form the data of the management accounting of all cash flows.

The transfer of key treasury functions of the production holding to third parties under an outsourcing agreement is not widespread in current Russian conditions due to several reasons, including high risks of "raider" seizure of business and fraud, lack of reliable outsourcing of financial companies in the market, as well as certain legislative restrictions.

In current conditions, the specific forms of organizing the treasury of a production holding and the functions assigned to it vary depending on the characteristics of the business, which include:

- the legal form of activity;
- the management structure;
- the business scale;
- the features of the tax regime;
- the historical features of the development of the holding;
- the nature of the relationship between management and owners.

The main functional tasks of corporate treasuries include tasks such as ensuring the necessary level of liquidity and solvency based on a balance of incoming and outgoing cash flows; determining the need for volumes of short-term and long-term financial resources; optimizing the structure of funding sources; organizing intercompany cash flows and cash flows from external operations; and developing and implementing the policies of financial risk management (currency, credit, interest, etc.).

The effectiveness of the treasury of the production holding should be based on the selection of a specific list of analytical indicators and clear criteria for assessing their levels. The main requirements for the formation of a system of performance indicators of the treasury are:

- the compliance of performance indicators with the best modern practices of organizing treasury operations, the current state and capabilities of the banking system, Russian and foreign financial markets;
- the consideration of the specifics of the holding management system;
- the uniformity and compliance with the applicability of treasury operations by companies included in the structure of the production holding;
- the relationship of performance indicators with the employee motivation system aimed at achieving the general strategic business goals of the holding; ensuring the priority of team results over personal ones; encouraging sensible initiative instead of following formal instructions;
- the compliance with the requirements of Russian and international legislation in the field of mutual settlements and financial transactions;
- the assessment of the total effect of treasury operations, taking into account the performance of each structural unit and personalizing the contribution of employees;
- the complexity and hierarchy of a system of indicators for ensuring compliance with different levels of authority and responsibility of executors and management engaged in treasury operations.

Of the functions assigned to the treasury of the production holding, one of the most significant is managing dealing operations, which are a necessary tool for solving the tasks of managing the company's liquidity, business financing, and financial risk management. Dealing operations of corporate treasuries include, as a rule, the attraction of money from various sources, use of free money as financial investments, purchase and sale of foreign currency, transactions with derivative financial instruments (derivatives).

The generation of income from operations on the placement of temporarily free funds (for a period of one day) through the use of such market instruments as bank accounts with interest on balances, bank deposits and certificates, bills of exchange, notes, highly liquid bonds, and currency swaps allow for the compensation of potential losses inherent in the excess accumulation of free cash assets.

Raising funds of the financial market is done both for the purpose of short-term financing of the economic activity of a manufacturing company, in the form of bank overdrafts and loans to compensate the cash gaps, as well as for the medium- and long-term financing of the process of accumulating the necessary resources for conducting business activities through loans and issuing bonds and shares.

The treasury of the holding is involved in all operations for raising and placing funds, though it organizes and responds, as a rule, only for short-term operations (from one day to a quarter or a year). The decisions on the need for longer financial transactions are made at the level of the management of the parent company of the holding; in the implementation of particularly large financial transactions, decisions are made by the owners.

The transactions on the purchase and sale of foreign currency can be performed to hedge financial risks and obtain additional income (speculative, from positive exchange-rate differences, etc.), in addition to providing the liquidity in the currency that is necessary for the fulfillment of the company's obligations. Similar to currency transactions, transactions with financial derivatives can be aimed both at managing the financial risks of a production holding (hedging) and at generating additional speculative income.

The intensification of dealing with operations in the work of corporate treasuries increases due to several factors [4]:

- increasing requirements for the quality of financial and other business risk management by owners and the state;
- development of information technology;
- development of financial markets;
- emergence of new financial instruments for managing cash flows and financial risks;
- stricter regulation of monetary circulation.

A study of the current level of the management of dealing operations' development by corporate treasuries in current conditions has shown the expediency of centralizing these functions, based on the parent company of the production holding by creating a separate specialized structural unit. When using the centralized treasury model, the management of dealing operations provides the following advantages [4]:

- an increase in the income from accumulating cash balances of all the group's companies in the parent company's accounts of the holding due to maximizing the volume of funds placed through cache-pooling technology as well as swapping due to the possibility of obtaining higher interest rates;
- the reduction in borrowing costs by maximizing the use of cash balances of the holding companies for fulfilling payment obligations, as well as minimizing interest rates on borrowed funds that are attracted by the parent company and acquire a higher solvency rating;

- the reduction of costs for hedging financial risks, including through financial derivatives, by taking into account the effect of diversification and netting of multidirectional risks;
- the reduction of specific operating costs due to an increase in the average volume of treasury operations during the release of personnel and lower-management costs (rental and maintenance of the office, hardware, and software, etc.);
- the concentration of knowledge and experience of the most effective employees of the financial departments of the holding, the effect of synergy;
- ensuring the necessary level of control over the implementation of the treasury policy, preventing financial abuse by the management of the companies included in the holding.

It is worth noting that, along with the advantages listed above, the centralization of treasury management in a production holding has one significant drawback: a decrease in the financial management interest of subsidiaries in effectively fulfilling the tasks of managing cash and financial risks solved by centralized treasury personnel.

Specialized literature on corporate financial management and methods for assessing the effectiveness of dealing with operations of enterprises is practically nonexistent. There are several reasons for this.

Firstly, in terms of placement and attraction of funds, the answer to the question of evaluating effectiveness may, at first glance, appear obvious: the higher the interest income received or, the lower the financial costs of servicing borrowed funds, the higher the efficiency, if the attraction prevailed over the placement. Moreover, as a rule, the treasury makes money short-circuited and places it into risk-free instruments, including account balances and deposits [1].

Secondly, if the corporate treasury practices the investment of available funds in risky assets (bills, bonds, financial derivatives, shares, etc.), then it is advisable to consider dealing operations as managing an appropriate portfolio of short-term investments and evaluating their effectiveness, such as by comparing the received income and the accepted risks using the Sharpe ratio [1].

The toolkit of such an investment analysis is presented in sufficient detail in several publications and is widely used by credit organizations, investment funds, and large corporations.

Thirdly, from the point of view of financial theory, it is impossible to systematically obtain returns above the risk-free rate in perfect markets (in which there are no transaction costs and taxes, investors cannot influence prices by their operations, and short [unsecured] sales are allowed) since high returns involve additional risk [1].

Also, experts note that corporations do not have sufficient competencies to make a profit in the financial markets, as they are inferior in several competitive positions to financial intermediaries (primarily large credit organizations). Financial intermediaries not only have higher personnel potential and their financial know-how but also have the asymmetry in the distribution of market information in their favor by using an extensive corporate clientele [5].

Three key indicators were identified for formulating a methodology for assessing the effectiveness of dealing operations of the centralized treasury of a production holding.

1. In order to assess the effectiveness of the placement of temporarily free cash, it is proposed to use the indicator: "The share of effectively placed temporarily free cash in the aggregate in all currencies." The analysis of the effectiveness of the placement of temporarily free cash is necessary to motivate management to increase the profitability of cash placement operations on bank accounts (including deposits), taking into account the specified level of risk. It is advisable to evaluate the level and dynamics of this indicator monthly for those enterprises of the production holding; functionality includes the corresponding evaluation indicator. This indicator is advisable to apply to the heads of the treasury departments of the holding companies since it reflects both the efficiency of placing temporarily free cash funds in deposits and the efficiency of the conditions for calculating interest on cash balances on settlement accounts.

   As part of the calculation of this indicator, the average weighted rate on deposits and balances on settlement accounts in each main functional currency is compared separately with a specified benchmark. It is advisable to use Mosprime rates on borrowings in rubles, Libor for US dollars and British pounds, and Euribor for euros.

   The benefits of this estimate are as follows:

   - the ability to compare the effectiveness of cash management by manufacturing holding companies;
   - the accounting not only the placement of temporarily free cash funds in deposits but also balances in current accounts, which allows a comprehensive assessment of the effectiveness of cash management;
   - the ability to compare the current dynamics of market rates and the effectiveness of the placement of temporarily free cash;
   - the calculation of the weighted average rate is carried out, taking into account all the basic parameters of the allocation of funds (amount, term, rate, frequency of interest payments, capitalization, and a base for calculating the number of days).

2. In order to assess the effectiveness of raising funds, it is proposed to use the indicator "The share of effectively attracted short-term credit funds in total for all currencies," which should be analyzed monthly for holding companies, where functionality includes an appropriate assessment indicator. For calculation and evaluation of this indicator, the weighted average rate on attracted short-term loan tranches (overdrafts) in each functional currency is compared separately with a given benchmark. As a benchmark, it is also advisable to use Mosprime rates on borrowings in rubles, Libor for US dollars and British pounds, and Euribor for euros.

The benefits of this estimate are as follows:

- the ability to analyze the current dynamics of market rates for short-term fundraising and compare them with the achieved level of profitability of operations on attracted short-term credit funds in the aggregate for all currencies;
- the ability to assess the effectiveness of operations on attracted short-term credit resources in the aggregate for all currencies, taking into account the volume and timing of short-term attraction.

3. In order to assess the effectiveness of conversion operations, it is proposed to use the indicator "Share of effectively converted funds" with a monthly frequency. This indicator should be applied to the employees responsible for conducting dealing operations and the management of the treasury department of the holding. As part of the calculation of this indicator, the weighted average spread for conversion operations is carried out in the context of each pair of convertible currencies individually with a given benchmark. It is proposed to use the volume-weighted average rate established at the currency section of the MICEX trading on instruments with target operating model "tomorrow" (TOM) as the primary target indicator in assessing the foreign exchange operations for currency pairs USD/RUB and EUR/RUB, which allows to follow the currency averaging strategy rate taking into account market impact (impact on market prices of operations of the parent company of the holding).

For currency pairs EUR/USD and GBP/USD, it is proposed to use the simple average indicator for quotations of the international currency market (Forex) for the period 10–00 to 18–00 (Moscow time) due to the lack of data on trading volumes of the international interbank currency market.

The benefits of this estimate are:

- the ability to take into account the current dynamics of the market rate;
- the lack of the ability to manipulate performance indicators by varying transactions with today and tomorrow's settlements.

As an integral comprehensive assessment of the effectiveness of dealing operations, it is proposed to calculate a summary indicator, which is the sum of all performance indicators for the above individual indicators of the effectiveness of dealing operations, weighted with the weight points of significance of each for assessing the effectiveness of treasury operations as a whole.

4 Discussion

The developed system of efficiency indicators of treasury operations of production holding is developed by taking into account developed administrative practice and the existing requirements to work in the treasuries of large corporations and the possible future trends dictated by the general business strategy.

The advantages of the proposed indicators of the effectiveness of financial transactions and the use of dealing should include:

- the possibility of using basic indicators generally accepted in the financial market, which allows one to take into account the influence of objective external market factors (interest rates, foreign exchange rates, etc.) on the results of the dealing operations of treasuries, to compare the effectiveness of the general dealing operations of a production holding company with external analogous corporations;
- the coverage of the main types of cash management operations using significant parameters (amounts, terms, rates, frequency of interest payments, capitalization, calculation base for the number of days, etc.) in terms of their placement (account balances or deposits) and attraction (overdrafts, loans, or swaps), allowing one to evaluate the effectiveness of dealing operations comprehensively;
- the ability to evaluate the performance of the basic functions of centralized treasuries related to conducting dealing operations at the level of executors, treasury management, and their headquarters;
- basing indicators on generally accepted market indicators to mostly solve the problem of their resistance to possible manipulation by unscrupulous employees;
- the proposed indicators that take into account the peculiarities of the current organization of the centralized treasury of the production holding and dealing operations (in particular, the indicators play the role of disciplining control indicators of the completeness of the centralized accumulation of free cash and their placement in various financial instruments to generate additional income);
- the relative simplicity of calculating and evaluating the effectiveness of dealing operations optimizes the procedures for assessing potential risks, limiting high-risk speculative transactions, investing money in the most reliable financial instruments;
- the indicators generally perform not only an information function, reflecting the level of effectiveness of each type of dealing operations, but also a motivating function, stimulating executives and treasury management to increase discipline in the implementation of legislative and internal requirements related to financial transactions.

5 Conclusion

The developed methodological approaches to the formation of a reliable system of analysis and evaluation of the quality of cash flow management (based on performance indicators of dealing operations) meet modern requirements and directions of developing financial management, the conditions of functioning of centralized treasuries, and the needs of corporate governance of vertically integrated production companies.

References

1. Braille, R., Myers, S.: Corporate Finance Principles. Olymp-Business, Moscow, Russia (2015)
2. Butorin, S.N., Bogoviz, A.V.: The innovational and production approach to management of economic subjects of the agrarian sector. Adv. Intell. Syst. Comput. **726**, 758–773 (2019)
3. Lobanov, A.A., Chugunov, R.A.: Encyclopedia of Financial Risk Management, 4th edn. Alpina Business Books, Moscow, Russia (2009)
4. Nabiev, R.A., Semenov, V.M.: Finance Organizations. Finance and Statistics, Moscow, Russia (2004)
5. Schiller, R.: Irrational Optimism. Alpina Publisher, Moscow, Russia (2013)

Organizational and Methodological Support for Self-Assessment Procedures with the Purpose of Preparing Integrated Corporate Reporting

Natalya A. Prodanova, Nataliya S. Plaskova, and Nadezhda G. Bochkareva

Abstract Complex, diverse, multidirectional institutional processes taking place around the world have led to the fact that the priority direction for disclosing information about activities of a reporting entity to its stakeholders is integrated corporate reporting. It is increasingly acting as a new effective tool of organization management that provides the necessary information connectivity and completeness of information disclosure on sustainable development of a business entity. The paper focuses on the organization's internal self-assessment, one of the effective methods used in the preparation of integrated corporate reporting. The authors substantiated the need for internal self-assessment in order to prepare integrated corporate reporting. They also provide suggestions to develop a methodology for self-assessment of the organization, as well as a number of proposals to improve the organizational and methodological support of the procedure for its implementation. Furthermore, the main content of the stages of internal self-assessment is discussed. A feature of the proposed methodological solution is the orientation to an in-depth analysis of the existing business model, the assessment of the contribution to the final result of the organization of each capital, taking into account the key characteristics of the internal and external environment, as well as industry specifics. The practical application of the proposed methodology as one of the corporate governance tools allows us to increase the standardization level of integrated reporting and ensure optimal management of financial and non-financial information flows.

Keywords Integrated corporate reporting · Self-assessment · Capital · Information · Interested users

N. A. Prodanova · N. S. Plaskova (✉) · N. G. Bochkareva
Plekhanov Russian University of Economics, Moscow, Russia
e-mail: plask55@mail.ru

N. A. Prodanova
e-mail: prodanova-00@mail.ru

N. G. Bochkareva
e-mail: nadia2334@rambler.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_9

1 Introduction

The existing accounting and information system of domestic organizations in the real sector of the economy is primarily focused on the collection and presentation of cost information and, therefore, is not well-suited for non-financial information in the formats required for its presentation in non-financial reporting. At the same time, the creation of a separate service dealing exclusively with this issue is often impractical due to the increased costs of collecting and processing the necessary information, of which a significant part, as a rule, is formed by various departments and organizations united in a business [4]. Under these conditions, an ordered—albeit distributed—mechanism for collecting information through internal self-assessment may become a possible solution.

2 Materials and Methods

As part of the study, an analysis of domestic experience in the formation of integrated corporate reporting was carried out. A systematic analysis of empirical research and the principles of formal logic, synthesis, and analysis of theoretical and practical materials were used as research tools. The author's approach to conducting a self-assessment, presented below, is based on survey materials as well as modern methodological developments considered in the relevant standards for building a management system focused on achieving success.

3 Results

From the point of view of the process of preparing integrated corporate reporting, self-assessment can be considered simultaneously as an internal questionnaire conducted independently by responsible executors and as a comprehensive, systematically organized analysis of the current business model, taking into account the fixed assets involved in it. Self-assessment can give a general idea of the organization's activities and the degree of maturity of its management system.

Internal self-assessment should be organized in such a way that on its basis, it would be possible to form a generalized (and in some cases a detailed) idea of all significant elements and segments of the business, the information about which will then be presented in an integrated report.

Self-assessment can be considered both as an internal analytical toolkit and as a kind of mechanism for replacing the continuous registration of objects and operations in traditional accounting registers. With the proper construction of a self-assessment system, it can provide the necessary level of completeness and reliability of the information presented in it, taking into account the requirements for the level of corporate transparency and information disclosure. Therefore, in relation to it, general approaches can be used that determine the basic requirements for any systems for ensuring business transparency, in particular:

- orientation to information, either contained in the management system or obtained on its basis using techniques of financial and statistical analysis, and modeling;
- focus on the information needs of the primarily interested users. Self-assessment procedures must be carried out so that "exactly the information that users need in a convenient form" is formed on its basis;
- the reliability, accuracy, and completeness of the information received, which should provide internal and external users with the opportunity to correctly and timely assess economic, environmental, social, etc., aspects of business activity, its opportunities for sustainable development and prospects for creating additional economic value in the future;
- the balance of costs and benefits from creating a self-assessment system, balancing risks and opportunities when using the information contained in it, that is business management should be well aware and able to balance the potential benefits of increased transparency and the costs and losses associated with them.

The main goal of the self-assessment is to achieve a comprehensive vision of the main internal processes, understanding how the selected business model is implemented on their basis. It is logical to consider the business model as an object of self-assessment through the types of capital involved in its implementation. A brief description of the main elements of each type of capital subject to the self-assessment procedure is given in Table 1.

Self-assessment should correspond to the specifics of the activity of a particular organization, giving a full, clear, reliable idea of all the components of the capital involved in the business. Additionally, it may include issues of ensuring corporate governance quality in such key areas as:

- the rights of shareholders and investors;
- the activities of the board of directors;
- the systems of corporate governance and organization of internal control;
- the actions aimed at disclosing information and increasing information transparency of a business;
- corporate social responsibility and business ethics;
- compliance in all key areas of activity, etc. [2].

In the expanded form, the self-assessment methodology should include a combination of questionnaires and census schedules presented in the form of tables. They are listed by the relevant structural, organizational units. Thus, through a systematic presentation of the organization's internal and external environment as "a combination of internal and external factors and conditions that can affect the achievement of the organization's goals and its behavior in relation to interested parties" [5], the necessary informational basis for the formation of an integrated corporate reporting is provided.

Table 1 The assessment of the impact of key types of capital on a business model

Type of capital	The investigated elements	The characterization of the results of the study
Financial	Sources of financing activities (strategic and current) Funding directions Financing risks Business capital evaluation Investment Information about future investment projects	Assessment of the ability for self-financing The financing potential, taking into account long-term plans Assessment of risks associated with the financing of activities and the effectiveness of measures for reducing them Assessment of the prospects for business growth
Industrial	Description of fixed assets by groups and categories Description of infrastructure facilities Organization of the production process Purchasing system and supply chain organization Marketing, sales policy, and distribution chain	Assessment of production and technical potential Assessment of production opportunities in terms of sustainable growth Assessment of the effectiveness of material support of production processes Assessment of sales opportunities
Intellectual	Quantity and value of copyright, licenses, patents, know-how, and other types of intangible assets Investments in research and development, the acquisition of new intangible assets The presence of intelligent infrastructure (business architecture, knowledge bases, internal networks) Descriptions of business processes and their configuration Personnel composition and average number of employees by divisions and segments Expenses for advanced training and additional education of employees. The acquisition of special knowledge Motivational and productivity programs	Assessment of the potential for creating added value based on existing intangible assets Analysis of potential returns on future investments in intangible assets Assessment of the professional and educational level of employees Assessment of staff experience and ability to perform work Technical and methodological equipment of labor Assessment of the contribution of employees in achieving the intended results

(continued)

Table 1 (continued)

Type of capital	The investigated elements	The characterization of the results of the study
Natural	Raw materials used and natural resources consumed The use of various types of renewable and non-renewable resources Business impact on the environment. Environmental expenditures Energy and resource-saving costs	Assessment of limitations and opportunities for the use of natural resources and raw materials Risks and opportunities of an existing business model within existing natural ecosystems Assessment of the impact of production activities on the environment
Social (relational)	The analysis of the system of relations with interested users of reporting information Social overhead costs The amount of remuneration and other payments to employees Costs for joint technologies, participation in vertical supply chains Costs of social investments, sponsorship, charity Costs of creating a public image and ensuring the openness of the business (presence on social networks, interaction with the media, communication with the public, etc.)	Assessment of the potential impact of interested users of reporting information on business Assessment of the effect of social investments, sponsorship, and charity in the regions where the business is present Assessment of the contribution of social (relative) capital to business results

Source Bochkareva and Prodanova [2]

Census schedules should be categorized into groups by subject, the nature of the evaluated area, and by business units (segments). In this case, two options for the self-assessment scheme can be envisaged: standard and extended.

The standard scheme assumes that a survey of business units is carried out on a common basis, without highlighting their specifics. The advantage of this approach is distinct—the questionnaires are formed in a standard form, the questions are the same, and the specifics can appear only at the level of answers. This option of self-assessment can be recommended to organizations that began to form integrated corporate reporting for the first time or relatively recently and have not yet created effective, well-functioning internal organizational and instrumental tools for the collecting and processing of relevant, non-financial information in the required presentation format.

The extended scheme assumes that the questioning of business units is carried out individually, taking into account the characteristics and information needs of internal users. In this case, the standard set of questions contained in the questionnaires can be modified by clarifying their wording, expanding, or, conversely, reducing the number of positions considered.

Such a scheme can be recommended to a business that has already repeatedly formed integrated corporate reporting and, accordingly, has the necessary experience and technical capabilities for improving the mechanisms and tools for its preparation.

It should be noted that, in general, the self-assessment procedure can be reduced mainly to filling out questionnaires and their subsequent processing. Accordingly, this process can be organized in two ways.

The first method can be characterized as the "bottom-up" principle. It suggests that pre-formed questionnaires with approved wording of answers can be sent directly to the units being examined. The leadership of the latter independently determines how to fill them out and who is responsible for this process, on the basis of internal regulations and orders of higher governing bodies. Accordingly, it is the heads of departments that are responsible for the accuracy and completeness of the information in the completed questionnaires.

In the second method, the inverse "top-down" principle is implemented when the questionnaire is carried out by a centralized unit or by an independent working group, whose mandate is to organize the self-assessment process directly.

The methods for conducting a self-assessment of capital are presented in Fig. 1.

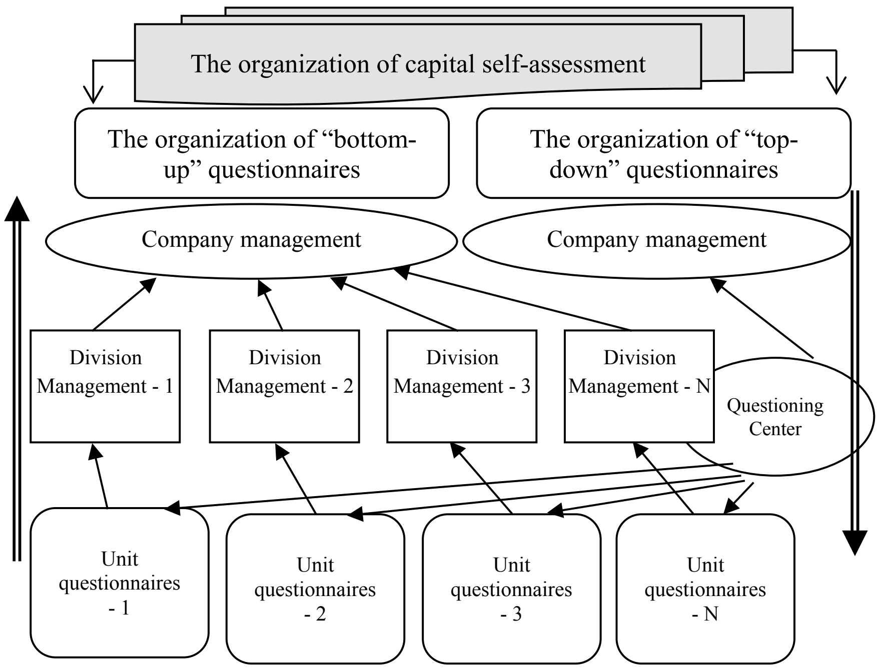

Fig. 1 The ways to organize and conduct self-assessment of the company's capital

The functions of the working group may include the following issues:

- ensuring the identification and elimination of local information restrictions that impede objective, timely, and full self-assessment;
- ensuring consistency in the organization of the questionnaire process with the management of the assessed units;
- establish effective and quick informational intra-organizational exchange of information, knowledge, and experience, stimulating close interaction between performers.

The responsibility for the accuracy and completeness of the information in the completed questionnaires is more centralized in that case.

To assess the capital, the content of the questionnaires provides questions with quantitative and qualitative characteristics. In this regard, at the level of internal methodological developments, it is advisable to distinguish between quantitative and qualitative information.

Self-assessment should not only help to identify general facts and patterns in the information collected, but also contribute to a better understanding by the staff of the importance of its role in the organization, an objective assessment of individual contribution to the creation of economic added value.

Based on the results of the self-assessment, additional measures aimed at solving problems can be taken:

- the organization of processes for the exchange of knowledge and experience, advanced training, building programs to introduce proposals for improving production processes and improving product quality;
- the improvement of systems of material compensation and intangible incentives, taking into account the individual contribution of the employee and his achievements;
- the creation of a career development system planned staff rotation in order to stimulate personal development and increase the professional competence of employees;
- the development of corporate mentoring and training programs for young professionals, etc.

4 Discussion

In the future, the role of the proposed self-assessment methodology for management purposes may turn out to be much broader. Its information content can be used to analyze the sustainability of development or increase the overall quality of management, identify areas that need development and improvement, formulate strategic priorities, and determine the sequence of implementation of specific managerial actions or decisions. Also, to enhance the overall information-analytical effect, a complete self-assessment methodology may include additional tools for analyzing internal processes and evaluating business results relative to the selected benchmark. As a result, the organization gets the opportunity to make qualitative and quantitative comparative assessments with other organizations in order to understand its market positions better, as well as track and monitor changes over a certain period from the standpoint of achieving the intended strategic goals and the formation of new strategic guidelines.

5 Conclusion

The organization should use self-assessment to identify opportunities for improvement and innovation, set priorities, and develop action plans to achieve sustainable success. The results of self-assessment show the strengths and weaknesses of the business, its maturity level, and the stage of the life cycle. Due to their use, the additional valuable information appears not only for business analysis but also for staff training in order to correctly present it with an understanding of the existing business model and the potential for creating value.

The proposed method of self-assessment, according to the authors, should be considered not so much as a mechanism for creating an additional accounting system or an alternative to the existing one, but as a management tool that allows the organization to manage and effectively use the flow of non-financial information optimally.

References

1. Bochkareva, N.G.: Methodological support for the preparation of integrated corporate reporting (Dissertation of the Candidate of Economics). Plekhanov Russian University of Economics, Moscow, Russia (2018)
2. Bochkareva, N.G., Prodanova, N.A.: Internal self-assessment of the organization as an important stage in the preparation of integrated corporate reporting. Account. Constr. Organ. **9**(175), 4–8 (2018)
3. Kaspina, R.G.: Institutional aspects of high-quality corporate reporting potential. Audit Statements **5**, 18 (2013)
4. Le, P.T., Harvie, C., Arjomandi, A., Borthwick, J.: Financial liberalisation, bank ownership type and performance in a transition economy: the case of Vietnam. Pac.-Basin Financ. J. **57**, 101182 (2019)
5. National Standard of the Russian Federation: GOST R ISO 9004–2010 from November 23, 2010. Rosstandart, Moscow, Russia (2010)
6. Polenova, S.N.: The institutional model of accounting and reporting regulation in Russia (Dissertation of Doctor of Economics). Financial University under the Government of the Russian Federation, Moscow, Russia (2012)
7. Sumkova, N.G.: External factors of influence on the accounting institute. Econ. Entrep. **4–1**(57–1), 824–831 (2015)

The Application of the System-Structural Approach for the Study of the Specifics of the Functioning of Investment and Construction-Holding During the Financial and Economic Crisis of the Resource Type

Victor Malinin and Leonid Valdshteyn

Abstract The purpose of the paper is to assess the impact of the resource type of the financial and economic crisis (FEC) on the investment and construction holding (ICH). The structural model of the ICH is presented, which includes all the steps and directions of activity of a typical enterprise. A model for the classification of the FEC is proposed based on the nature and place of changes in the flows of the economic environment. The resource type of the crisis is examined in detail with the identification of the main causes of its occurrence and potential consequences for the construction business. The systemic effect of the FEC on the ICH is shown, highlighting the main elements of the external economic environment and their relationships, taking into account the specifics of the construction industry. Quantitative and qualitative indicators characterizing the FEC in terms of their impact on the IS, including those that allow us to assess the company's dependence on external factors, are also provided in the paper and critically analyzed. The analysis of the economic condition of the enterprise using the developed indicators allows us to form managerial decisions. In turn, the managerial decisions allow to level the potential consequences of the resource type crisis in case of its occurrence, focusing on increasing the financial and economic efficiency of the enterprise.

Keywords Financial and economic crisis · Resource crisis · Investment and construction holding · Development · Crisis indicators

V. Malinin · L. Valdshteyn (✉)
Moscow Bauman State Technical University, Moscow, Russia
e-mail: valdshteyn@yandex.ru

V. Malinin
e-mail: victor.malinin@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_10

1 Introduction

The development of the economic environment in recent decades has been taking place during a period of continuous turnover of financial and economic crises (hereinafter referred to as FEC), as shown in Fig. 1, as well as in the early works of the authors Valdshteyn and Malinin [13]. The works of Kapkaev and Kadyrov [5], Rudyi [7], and Anikin [1] played a major role in the research.

The specifics of the construction industry as a whole and, in particular, the direction of housing construction, make this industry particularly dependent on the FEC. The main features of the housing construction market are the following:

- long production and sales cycles;
- focus on households (b2c market);
- high capital intensity.

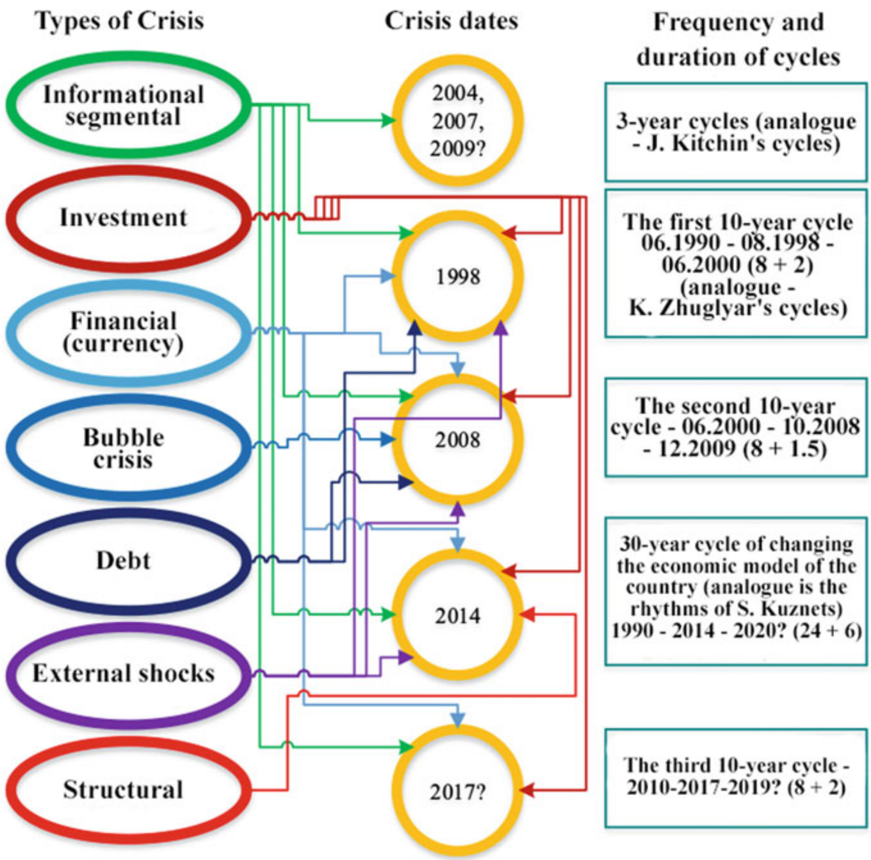

Fig. 1 Types, frequency, and duration of cycles and crises in the Russian economy and real estate market [9]

The factors discussed above, as well as the Decree of the President of the Russian Federation, "On National Goals and Strategic Tasks of the Development of the Russian Federation for the Period until 2024" (May 05, 2018 No. 204) and, in particular, the need to increase "the volume of housing construction to at least 120 million m^2 per year" under the current conditions, do the research aimed at developing an operational assessment of the current economic environment to ensure early management impact, are particularly relevant. The existing works today do not offer a comprehensive analysis of the FEC in qualitative and quantitative indicators, as applied to the ICH. These indicators can also be formed as multifactor functions that are not applicable in a real business because of the complexity of the calculations. In this area, one can note, among others, the work aimed at introducing indicators in assessing the performance of enterprises [2, 10] and analysis of a construction company during the crisis [11].

The aim of this work is to systematize the FEC and structure their impact on the construction industry in the form of investment and construction holding (hereinafter referred to as ICH). In order to achieve this goal, the following tasks are set:

1. to explore the structure of the ICH;
2. to classify the FEC;
3. to develop a model of FEC;
4. to evaluate the impact of the proposed types of FEC on the ICH.

2 Materials and Methods

2.1 The Structure of Investment and Construction Holding

The ICH is what follows from the name itself, a symbiosis of the investment (or financial) block with the construction division. The first can be either a majority shareholder or a pool of investors or a financial (e.g., banking) organization that provides continuous financing of the project. Combinations of all the considered options are also possible.

The development unit is responsible for the building block that oversees the entire process from the selection of the land plot to the stage of putting the constructed property into operation, transferring it to the ultimate owners, and its further operation. If the indicated areas of activity determine the horizontal structure of the development block, then the use of directly-owned resources determines its vertical structure.

The issue of using own capacities for the operation of a particular block or using contractor organizations to carry out design projects is relevant for conducting efficient economic activities of the ICH, especially during the FEC period, and was considered in detail [12]. In this work, it is indicated that the vertical structure of the enterprise is largely regulated by the volume and location of the projects, as well as the production capacities.

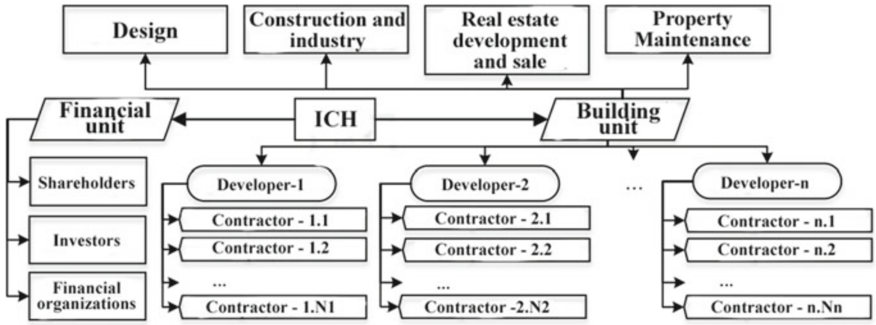

Fig. 2 The structure of the ICH

Within the framework of the project activity of the ICH itself, the activity structure is built as the interaction between the customer, developers, and contractors.

Then, the general structure of the ICH will look as shown in Fig. 2.

2.2 The Systemic Presentation of the Financial and Economic Crisis

The model developed by V. L. Malinin was adopted as the basic FEC model [6], simplified by the specifics of the study. The economic environment is divided into six components, namely:

1. The state that determines the costs of management, defense, social programs, education, subsidies, etc.;
2. Households: the final consumers of the produced goods;
3. The Central Bank: the regulator of the monetary policy of the state;
4. Commercial banks: a source of financing;
5. Currency exchange: an operator that determines currency fluctuations in the market;
6. Enterprises and manufacturers oriented to the domestic market (ever after referred to as domestic enterprises);
7. Enterprises and manufacturers oriented to the foreign market (exporters and importers).

All these components of the economic environment interact with each other, as well as with external components, ensuring the functioning of the entire system. Failure or a sharp change in connections leads to a failure of the system, which is manifested as FEC.

Depending on the nature and place of the change in the system flows, various types of FEC are shown in Fig. 3.

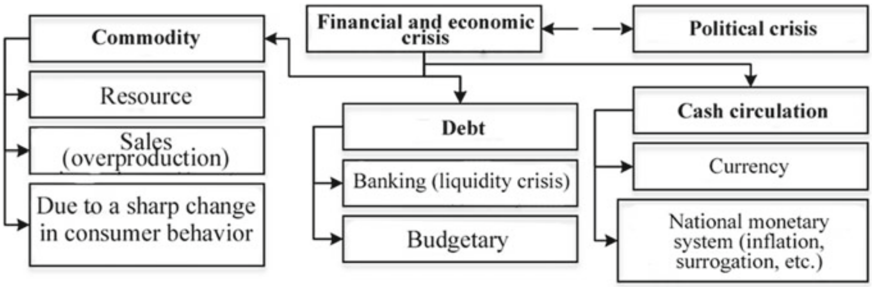

Fig. 3 The classification of the FEC. *Source* Developed by the authors based on the work [6]

2.3 The Study of the Systemic Impact of the Financial and Economic Crisis on Investment and Construction Holdings

To assess the specifics of the functioning of the ICH during the FEC period, the authors identified three components: money, debts, and goods that form the model of financial and economic activity of the ICH. The interaction of the components of the ICH system with each other and the external environment is presented in Fig. 4 and can be described by the flow-stock method.

$$Stock(t+1) = Stock(t) + Stock(Incoming - Outgoing)(t, t+1) \quad (2.3.1)$$

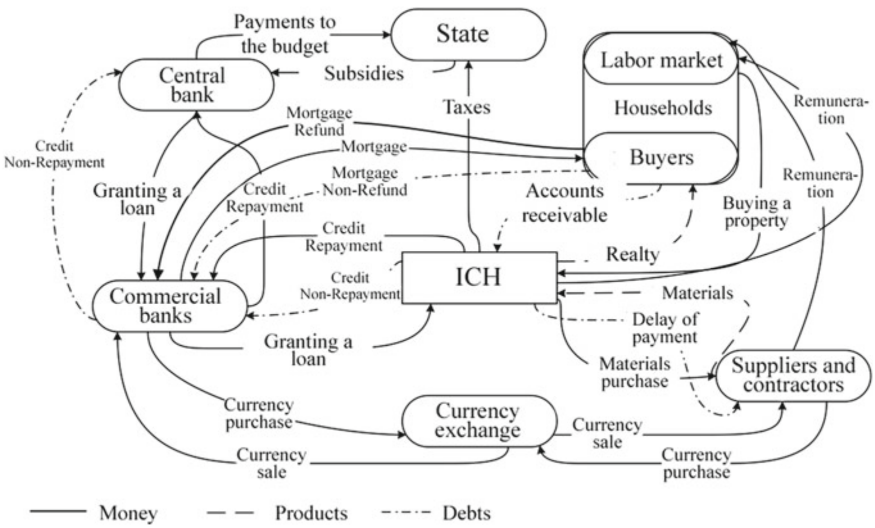

Fig. 4 The channels of influence of the macroeconomic system on financial and economic activities of the Institute of Agricultural Sciences

Depending on the current type of FEC, various blocks of the ICH model are mainly affected.

Within the framework of the proposed crisis typification, its own indicators are developed for each type, denoted as α_i, and clearly characterizing either the crisis itself or the dependence of the enterprise in question on it. In this paper, we will consider in detail the resource type of a crisis.

3 Results

Active industrial development and a generally stable high demand for real estate certainly cause a shortage of resources, wherein even a small external impact can lead to crisis.

The main message of the emergence of a resource crisis is the limited access to resources. The most tangible consequences, as discussed in [13], may be a change in the cost of the final product and/or a decrease in production (number of projects).

The reasons for this may be the following:

- cartel conspiracy;
- sanctions (import ban introduced both by the international community and by national authorities);
- rising prices for imported products;
- resource shortages caused by natural or political factors.

From the point of view of the construction business, the resource crisis can have two aspects—resources, such as materials used for the production of final goods, and land resources, such as sites for new projects. Despite the import substitution program [3], the developers are actively attracting imported building materials to increase the competitiveness of their projects, which increases their dependence on the external market.

The presence or potential use of a land bank is a prerequisite for the growth of a development business. In the absence of new sites for construction, neither sufficient provision of financial resources nor the use of modern construction methods will ensure the successful development of the area.

Separately, it is worth paying attention to the housing renovation program launched in Moscow [4], which has begun the active releasing of land assets of the city for large developers participating in the program, which will inevitably lead to another surge in construction in the city. In turn, a sharp increase in the number of projects, according to the authors, will invariably lead to a decrease in the cost of the final product, as a result of which the resource crisis can be replaced by a crisis of overproduction.

In analyzing the resource crisis in the framework of the systematic representation of the ICH model and its interaction with the economic environment presented in Fig. 4, it is worth highlighting the steps noted in Fig. 5, which are formed in the process of this type of crisis:

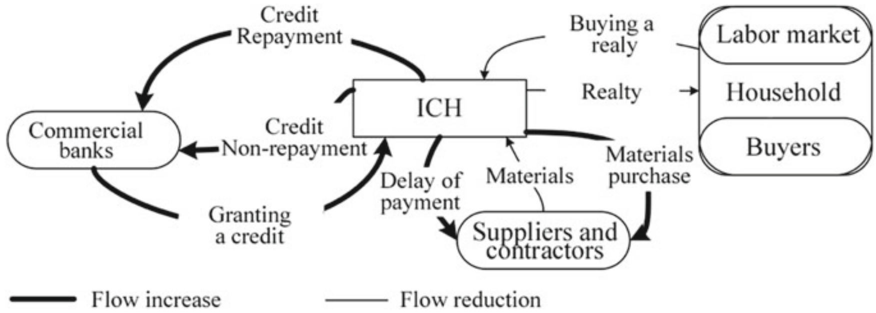

Fig. 5 The changes in the flows of the macroeconomic system of the ICH during the resource crisis

1. the increase in the cost of materials entails:
2. the delays in payment for materials;
3. the reduction in the materials supply;
4. the slowdown in construction;
5. the growth in property value;
6. the fall in the rate of sales;
7. the increase in payable accounts;
8. the risk of non-repayment/delay in payment of loans.

4 Discussion

In the framework of this type of crisis, the main indicator is the change in the cost of construction α_1, formed by the cost of materials and work, which excess by more than 5–10% directly affects the price of the final product, which in the face of hypercompetition can play a significant role for the company. The second indicator can be the number of new α_2 projects, that is, the development of the company's portfolio, the absence of which leads to the withdrawal of funds from this type of business, and its complete transformation for other goals and objectives of the shareholders. The average term for the implementation (sale) of residential real estate projects nowadays is about 2 years, while the production of the project, starting from the search for a land plot, takes about 3–4 years. With the right strategy for implementing and building a financial model, the implementation of primary real estate is divided into several periods: the start of sales, active sales, sale of balances, and sale of finished housing (after commissioning), as shown in Fig. 6.

Thus, a resource crisis can be fixed when one of the conditions is:

$$\alpha_1 = \frac{S_t}{S_{t-1}} > i + 5 - 10\% \quad \text{and/or} \quad \alpha_2 = 0 \text{ at } t > t_4,$$

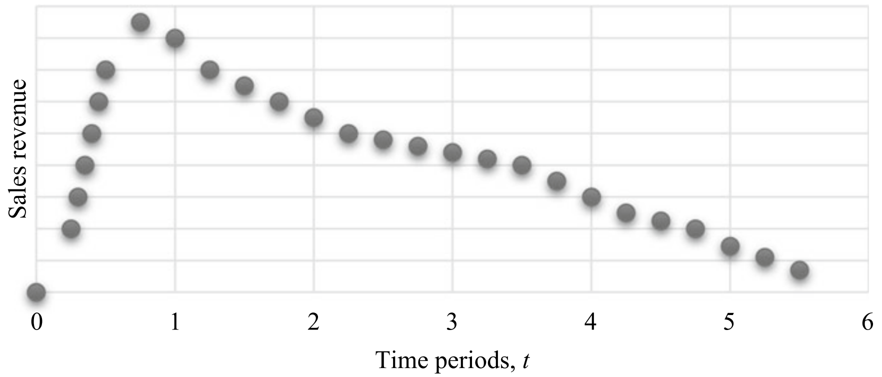

Fig. 6 The changes in revenue from real estate sales during the implementation of the project, where: t_0–t_1—start of sales; t_1–t_3—active sales; t_3–t_4—disposal of balances; t_4–t_6—commissioning and sale of finished housing

where:

i the current inflation.
S_t the cost at time t.

It is worth noting that the second condition is correct if the projects are financed through project banking financing, taking into account the latest changes to the Federal Law on shared construction (State [8], when it becomes impossible to redistribute funds from project to project even within a group of companies.

5 Conclusion

The application of the developed indicators in the analysis of the current economic condition of the enterprise allows us to quickly assess the company's dependence on external factors that form the resource crisis, in particular for making a preventive managerial decision aimed at improving the financial stability of the enterprise in an unstable environment.

In further works, the authors plan to study in more detail the issue of the impact of other types of FEC on the ICH with the development of recommendatory management solutions for operational impact on the enterprise in order to increase the financial efficiency of activities, including during the FEC.

References

1. Anikin, A.V.: About the typology of financial crises. MSU Bull. (Econ. Ser.) **4**, 43–54 (2001)
2. Bekirova: Formation of an array of indicators characterizing the activities of the construction company. Econ. Manag. Control Syst. **7**(1), 16–27 (2013)
3. Government of the Russian Federation: On approval of the state program of the Russian Federation “Development of industry and increase of its competitiveness”, 15 April 2014, no. 328, Moscow, Russia (2014)
4. Housing Renovation Program: Retrieved from https://stroi.mos.ru/novaia-proghramma-rienovatsii-piatietazhiek (n.d.)
5. Kapkaev, Y.S., Kadyrov, P.R.: Features of the cyclical development of the economy. Basic Res. **10–3**, 587–593 (2017)
6. Malinin, V.L.: The use of systemic, synergistic and situational approaches for the classification, modeling and prevention of financial and economic crises (Dissertation of Candidate of Economic Sciences). Moscow State University of Economics, Statistics, and Informatics, Moscow, Russia (2005)
7. Rudyi, K.V.: Financial Crises: Theory, History, Politics. New Knowledge, Moscow (2003)
8. State Duma: Federal law “On participation in the shared construction of apartment buildings and other real estate objects and on introducing amendments to some legislative acts of the Russian Federation”, 30 Dec 2004, no. 214-FZ, ed. 25 Dec 2018. Moscow, Russia (2004)
9. Sternik, G.M., Sternik, S.G.: Factors and trends in the development of the Russian market of multi-family housing at the end of 2017. Hous. Strat. **5**(3), 251–304 (2018)
10. Tishchenko, A.N., Khaustova, V.E., Belyaev, A.S.: Assessment of the competitiveness of construction enterprises with regard to their specificity. Probl. Econ. (Kharkiv) **1**, 185–190 (2013)
11. Torgashina, I.G.: Housing construction in times of crisis. News Irkutsk State Econ. Acad. **6**(2), 17 (2015)
12. Valdshteyn, L.V.: Vertical restructuring in a construction holding company during the period of financial and economic crisis. Reg. Econ.: Theory Pract. **15**(7), 1202–1211 (2017)
13. Valdshteyn, L.V., Malinin, V.L.: The use of a system-structural approach to analyze the impact of financial and economic crises on the construction industry in Russia. Mod. Sci. Thought **6**, 124–131 (2017)

Fuzzy-Multiple Methodology for Estimating the Risk of Bankruptcy of an Enterprise Based on a Complex of MDA Models and Matrix Aggregation Schemes

Lyudmila V. Sakharova, Tamara B. Alekseychik, and Alla A. Vasilenko

Abstract The aim of the paper is to develop a methodology for a comprehensive assessment of the bankruptcy risk of an enterprise based on fuzzy-multiple aggregation of estimates obtained through the use of a combination of classical models. The methodology is based on the use of fuzzy multi-level classifiers. It allows aggregating estimates by three groups of selected models, in which the enterprise is evaluated by a number of quantitative models. It should be noted that the analysis applies only those indicators that most reflect the possibility of bankruptcy. At the final stage, the normalized bankruptcy risk assessments obtained in each of the groups are aggregated into the final assessment, which is an integral indicator of the bankruptcy risk of an enterprise. The novelty of the proposed method lies in the possibility of combining the conclusions obtained on the basis of unified methods using various evaluation criteria, as well as in the possibility of taking into account their weight coefficients in the model, reflecting the reliability of the models for the studied group of enterprises.

Keywords Comprehensive assessment · Aggregation · Fuzzy-multiple technique · Fuzzy-logic systems · Bankruptcy risk

1 Introduction

The task of determining the degree of bankruptcy risk of an enterprise is relevant for all persons interested in the financial situation of the enterprise: management, owners, investors, creditors, tax and administrative authorities, etc. In a financial analysis, a number of indicators that characterize certain aspects of the current financial situation of an enterprise are well known.

L. V. Sakharova (✉) · T. B. Alekseychik · A. A. Vasilenko
Rostov State University of Economics, Rostov-on-Don, Russia
e-mail: L_Sakharova@mail.ru

T. B. Alekseychik
e-mail: alekseychik@mail.ru

A. A. Vasilenko
e-mail: allvasilenko@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_11

Based on these indicators, a large number of integral coefficients have been developed that characterize the general situation and probability of bankruptcy of the enterprise. First of all, these are the so-called MDA-models or models built using multiple discriminant analysis. These are statistical models, which construction is carried out on the basis of statistical data of financial statements. These include the Altman Model, Fox Model, Tuffler Model, Irkutsk Model (hereinafter IEGE), Fulmer Model, etc. Among the most famous works in which models were created using this method, the following can be noted: [1–4, 6, 9, 13–16, 19].

The algorithm for constructing all MDA models includes five points: (1) the formation of a sample of bankrupt enterprises; (2) the formation of a sample of non-bankrupt enterprises; (3) the calculation of financial ratios for both groups; (4) the construction of a regression equation that classifies all enterprises into bankruptcies and non-bankruptcies, using the multiple discriminant analysis (MDA) tools; (5) checking the adequacy of the constructed model.

The paper [5] analyzes the results of applying foreign and Russian models to the financial statements of Russian enterprises. It has been established that for the prediction of bankruptcy, the so-called "classic" Western models (Altman, Tuffler, Springate) are more effective than the models originally built by Russian companies. Table 1 shows the results of applying classic western models and Russian models:

From Table 1, the results of using foreign models are generally ambiguous: models with high overall reliability are not very good for groups of bankrupt and non-bankrupt, and models that work well for a group of bankrupts are ineffective for "healthy" companies and have low overall reliability.

Thus, it is impossible to say that there are currently absolutely reliable MDA models, which can be the basis for obtaining reliable information about the risk

Table 1 The effectiveness of classic Western and Russian bankruptcy prediction models

Model	Overall accuracy (%)	Precision (%)	Sensitivity (%)	Specificity (%)	F-measure (%)
Classic Western models					
Altman model	77.5	71.2	92.3	62.6	80.4
Fulmer model	82.0	85.0	77.7	86.3	81.2
Springate model	77.2	70.7	93.2	61.3	80.4
Tuffler model	73.9	66.7	95.5	52.3	78.5
Zmievsky model	78.9	72.4	93.7	64.2	81.6
Classic Russian models					
Sayfullin-Kadykov model	70.0	64.9	87.2	52.9	74.4
Davydova-Belikova model	75.7	73.9	79.3	72.1	76.5
Zaitseva model	58.6	55.5	86.3	30.9	67.5

Source Fedorova et al. [5]

of enterprise bankruptcy. As a result, the reliability of the study increases with the simultaneous use of several models, both foreign and domestic.

The problem is that, with the simultaneous use of several models in practice, a scattered result is often obtained; for some models, the probability of bankruptcy is high, and for others, it is low. Therefore, an important task is to combine the results and form quantitative estimates based on the totality of estimates calculated with the use of various models. At the same time, estimates, like some "average values" obtained on the basis of models for bankruptcy risk assessment by traditional methods, are not possible, since the models are not unified, have different criteria, and also distinguish a different number of enterprise conditions.

The most promising solution to the problem is the aggregation of estimates based on fuzzy logic methods [10–12]. The foundations of the theory of fuzzy sets are presented in the work of Lofti Zadeh [18]. The greatest effect, when using the fuzzy set method, is characteristic for evaluating processes that are based on subjective judgments. This applies both to estimates of the probability of bankruptcy and to the audit as a whole.

Audit, as a process based on the subjective judgments of the auditor, also involves assessing the reliability of the financial statements in the face of uncertainty. In the study of approaches to the assessment of audit risk, the possibilities of using the fuzzy set method by the auditor are described [8]. Iranian scientist Zohreh Hajiha simulates the entire fuzzy audit risk modeling algorithm [7]. The possibilities of using the tools of the theory of fuzzy sets for the purpose of taking optimal actions in the planning process of audit procedures are also investigated [17].

Systems of fuzzy-logical conclusions, primarily matrix aggregation systems, allow one to build system estimates based on a set of indicators, taking into account their weight coefficients. In addition, systems of fuzzy-logical conclusions allow us to take into account expert assessments, which is an indisputable advantage when adapting the mathematical apparatus of research for solving the problems facing the domestic economy.

2 Materials and Methods

The method of aggregation of enterprise bankruptcy risk estimates calculated on the basis of a number of well-known MDA models is developed.

The study was based on 13 foreign and domestic methods implemented on the basis of the service afdanalyse.ru/Example/Analiz_Ball_1.xls. A brief description of the techniques available on the same site is shown below.

1. **Altman two-factor model**:

$$Z = -0.3877 - 1.0736 * \mathrm{Rcl} + 0.0579 * (\mathrm{BC/E}),$$

where Rcl is the current liquidity ratio, BC is borrowed capital, and E is equities. Conclusion: If $Z < 0$, it is less than 50% and decreases with a decrease in Z; if $Z = 0$, it is approximately equal to 50%; if $Z > 0$, it is more than 50% and increases with increasing Z (3 states).

2. **Modified five-factor Altman model**:

$$Z = 0.717X1 + 0.847X2 + 3.107X3 + 0.42X4 + 0.998X5,$$

where X1 is the working capital to the amount of assets and estimates the amount of the company's net liquid assets in relation to total assets, X2 is retained earnings to the total assets of the enterprise and reflects the level of financial leverage of the company, X3 is profit before tax to the total value of assets and reflects the effectiveness of the company's operations, X4 is the book value of equity/borrowed capital (liabilities), and X5 is sales to the total assets of the enterprise and characterizes the return on assets of the enterprise. Conclusion: If $Z < 1.23$, there is a high risk; if Z is from 1.23 to 2.89, there is no certainty; and if Z is more than 2.9, there is a low risk (3 conditions).

3. **Altman model for non-manufacturing companies**:

$$Z = 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4,$$

where X1 is Working Capital/Total Assets; X2 is Retained earnings/Assets; X3 is Profit before tax/Assets or EBIT/Assets; X4 is Equity/Liabilities. Conclusion: if $Z \leq 1.1$, it is high risk; if Z is in the range from 1.1 to 2.6, the situation at the enterprise is stable; if $Z \geq 2.6$ the situation is unstable (3 states).

4. **Altman model for emerging markets**:

$$Z = 3.25 + 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4,$$

where X1 is WorkingCapital/TotalAssets; X2 is Retained earnings/Assets; X3 is Profit before tax/Assets or EBIT/Assets; X4 is Equity/Liabilities. Conclusion: if Z is equal to or less than 1.1, the situation is critical, and the organization is highly likely to go bankrupt; if the value of the indicator Z is equal to or exceeds 2.6, it is an unstable situation, and the probability of bankruptcy of the organization is small but not excluded; if the Z indicator is within the range of 1.10–2.6, the probability of bankruptcy of the organization is low (3 states).

5. **Tuffler-Tishou Model**:

$$Z = 0.53X1 + 0.13X2 + 0.18X3 + 0.16X4,$$

where X1 is the ratio of profit before tax to the number of current liabilities, X2 is the ratio of current assets to total liabilities, X3 is the ratio of current liabilities to total assets, and X4 is the ratio of revenue to total assets. Conclusion: if $Z > 0.3$ is the probability of bankruptcy is low; when $0.2 < Z < 0.3$ is the state of uncertainty; when $Z < 0.2$ is a high probability of bankruptcy (3 states).

6. **Fulmer Model**:

$$\begin{aligned} H = {} & 5.528X1 + 0.212X2 + 0.073X3 + 1.270X4 - 0.120X5 \\ & + 2.335X6 + 0.575X7 + 1.083X8 + 0.894X9 - 6.075, \end{aligned}$$

where X1 is retained earnings of previous years [1]/balance sheet [1], X2 is sales revenue/balance [1], X3 is profit before tax/equity, X4 is cash flow/long-term and short-term liabilities [1], X5 is long-term liabilities [1]/balance [1], X6 is short-term liabilities/total assets [1], X7 is log (tangible asset), X8 is working capital [1]/long-term and short-term liabilities [1], and X9 is log (profit before tax + interest payable/interest paid). [1] is average value for the period (value at the beginning + value at the end of the period)/2. Conclusion: The onset of insolvency is inevitable when H < 0 (2 states).

7. **Springate Model**:

$$Z = 1.03X1 + 3.07X2 + 0.66X3 + 0.4X4,$$

where: X1 = Working capital/balance; X2 = EBIT/balance; X3 = EBIT/Short-term liabilities; X4 = Revenue (net) from sales/Balance. Conclusion: at Z < 0.862, the company is a potential bankrupt (2 states).

8. **Model of the Irkutsk State Economic Academy (ISEA)**:

$$R = 8.38X1 + X2 + 0.054X3 + 0.63X4,$$

where: X1 is net working capital/assets; X2 is net income/equity; X3 is net income/balance sheet currency; X4 is net profit/total costs. Conclusion: if R is less than 0, the probability of bankruptcy is maximum (90–100%); if R = 0.18, high (60–80%); if R = 0.18–0.32, average (35–50%); if R = 0.32–0.42, low (15%—20%); if R is more than 0.42, minimal (up to 10%) (5 states).

9. **Lis Model**:

$$Z = 0.063X1 + 0.092X2 + 0.057X3 + 0.0014X4,$$

where: X1 is working capital/total assets; X2 is profit from sales/amount of assets; X3 is retained earnings/amount of assets; X4 is equity/borrowed capital. Conclusion: if Z < 0.037—high probability of bankruptcy; if Z > 0.037—low probability (2 states).

10. **O. P. Zaitsev Model**:

$$K = 0.25X1 + 0.1X2 + 0.2X3 + 0.25X4 + 0.1X5 + 0.1X6$$

where: X1 is the coefficient of loss-making enterprises; X2 is the ratio of payable and receivable accounts; X3 is the ratio of short-term liabilities and most liquid assets; X4 is the loss on sales of products, characterized by the ratio of net loss to the volume of sales of these products; X5 is the financial leverage (financial risk) ratio; X6 is the asset utilization ratio as the reciprocal of asset turnover ratio.

It is necessary to compare the actual value of Kfact with the standard value (Kn), which is calculated by the formula:

$$\begin{aligned} \mathrm{Kn} = {} & 0.25 * 0 + 0.1 * 1 + 0.2 * 7 + 0.25 * 0 + 0.1 * 0.7 \\ & + 0.1 * \mathrm{X6(last\ year)} \end{aligned}$$

Conclusion: if the actual ratio is higher than the normative Kfact > Kn, then the probability of bankruptcy of the enterprise is extremely high; if less, then the probability of bankruptcy is negligible (2 states).

11. **R. S. Sayfullin and G. G. Kadykov Model**:

$$\mathrm{R} = 2\mathrm{X1} + 0.1\mathrm{X2} + 0.08\mathrm{X3} + 0.45\mathrm{X4} + \mathrm{X5},$$

where: X1 is the ratio of own funds; X2 is the current liquidity ratio; X3 is the advance capital turnover rate; X4 is the management ratio; X5 is the рентабельность собственного капитала. Conclusion: $R < 1$ means an unstable state; $R \geq 1$ means a stable state (two states).

12. **V. V. Kovalev Model**:

$$\mathrm{N} = 25\mathrm{N1} + 25\mathrm{N2} + 20\mathrm{N3} + 20\mathrm{N4} + 10\mathrm{N5},$$

where N1 is the stock turnover ratio, N2 is the current ratio, N3 is the capital structure ratio, N4 is the return on assets: profit before tax/assets, and N5 is the efficiency ratio: profit before tax/revenue from sales. Conclusion: $N \geq 100$ means a good financial position; $N < 100$ means a negative financial position (two states).

13. **G. V. Savitskaya Model**:

$$\mathrm{Z} = 0.111\mathrm{X1} + 13.239\mathrm{X2} + 1.676\mathrm{X3} + 0.515\mathrm{X4} + 3.80\mathrm{X5},$$

where X1 is the share of working capital in the formation of current assets, X2 is the working capital to fixed capital ratio, X3 is the ratio of the total capital turnover, X4 is the return on assets, and X5 is the financial independence ratio. Conclusion: With a value of Z higher than 8, the risk of bankruptcy is small; with a value of Z from 8 to 5, there is a small risk of insolvency; with a value of Z from 5 to 3, there is an average risk of bankruptcy; with a value of Z below 3, the risk is high; with a value of Z below 1, the company is bankrupt (five states).

As can be seen from the descriptions of the models, 5 of them (formally) distinguish two states of the enterprise in relation to the risk of bankruptcy; 6—three states and 2—five states.

In order to aggregate information, the so-called matrix data aggregation schemes are used: fuzzy multi-level [0, 1]—classifiers, two-, three- and five-point.

Let us define the segment of the real axis [0, 1] as the carrier of the linguistic variable. We introduce a linguistic variable "BR (bankruptcy risk)" with a term-set of values G, consisting of three terms: G1—"BR low", G2—"BR medium", and G3—"BR high".

The matrix data aggregation scheme based on three-level fuzzy classifiers is based on the formula:

$$g = \sum_{i=1}^{N} p_i \sum_{j=1}^{3} \alpha_j \mu_{ij}(x_i),$$

where α_j is nodal points of the standard classifier (centers of gravity of terms), p_i is the convolution weight of the *i*th factor, $\mu\alpha\nu\delta_{ij}$ (x_i) is the value of the membership function of the *j*th quality level relative to the current value of the *i*th factor.

Then the exponent *g* is recognized based on the standard fuzzy classifier, in accordance with the indicated membership functions.

If the linguistic variable "BR (bankruptcy risk)" is described by a term set of five terms (G1—"BR is very low"; G2—"BR is low"; G3—"BR is medium"; G4—"BR is high"; G5—"BR is very high"), then we get the standard five-point [0, 1]—classifier.

Finally, if the linguistic variable "BR" is described by a term set of two terms (G1 is "BR low"; G2 is "BR high"), we obtain the simplest binary classifier.

Multipoint classifier systems allow us to calculate a comprehensive assessment of the bankruptcy risk of an enterprise by normalizing estimates and aggregating them based on matrix schemes.

3 Results

A study of the bankruptcy risk of OJSC Donskoye was carried out on the basis of the financial statements for 2016–2017. In the first step, using the two-point classifiers, 6 models with two terms were aggregated; in the second step, 5 models with three terms are aggregated; and in the third step, 2 models with five terms are aggregated. Finally, in the fourth step, the final comprehensive bankruptcy risk assessment is built on the basis of three groups of models using standard three-point classifiers. At the same time, it was believed that all models are at equilibrium (weights can be varied). The results of a direct calculation of bankruptcy risk by model are shown in Table 2. The process of aggregating the results is presented in Table 2 (Tables 3, 4, 5 and 6).

Table 2 The results of the evaluation of the enterprise BR on the basis of the financial statements of the OJSC Donskoye based on MDA models

Model (number of terms)	Conclusion			
	2016	Indicator	2017	Indicator
1. Altman two-factor model (3)	Below 50%	Z = −5.16	Below 50%	Z = −2.70
2. Modified five-factor Altman model (3)	Low	Z = 4.40	No def	Z = 2.65
3. Altman model for non-manufacturing companies (3)	50%	Z = 11.58	50%	Z = 5.53
4. Altman model for emerging markets (3)	Stable	Z = 14.83	Stable	Z = 9.78
5. Tuffler-Tishou model (3)	Low	Z = 1.95	Low	Z = 0.90
6. Fulmer model (2)	Low	H = 6.90	Low	H = 4.01
7. Springate model (2)	Low	Z = 3.86	Low	Z = 2.06
8. Model of the Irkutsk State Economic Academy (5)	To 10%	R = 5.43	To 10%	R = 3.57
9. Lis model (2)	Low	Z = 0.09	Low	Z = 0.06
10. O. P. Zaitseva model (2)	Low	K = 0.36 (Kn = 1.72)	High	K = 6.10 (Kn = 1.70)
11. R. S. Sayfullin and G. G. Kadykov model (2)	Stable	R = 2.63	Stable	R = 1.72
12. V. V. Kovalev model (2)	Good	N = 378.57	Good	N = 195.33
13. G. V. Savitskaya model (5)	Small risk	Z = 5.08	Medium risk	Z = 3.28

Source Compiled by the authors

4 Discussion

Thus, the final aggregate estimate, built on the basis of the considered models, has a numerical value of 0.31 (in accordance with the theory of fuzzy sets, we can assume that this is the probability that the expert will classify the enterprise in the

Table 3 The aggregation of BR estimates obtained on the basis of MDA models distinguishing the two states (G1/"BR low"; G2/"BR high")

Model	2016		2017	
	Term			
	G1	G2	G1	G2
1. Fulmer model	1	0	1	0
2. Springate model	1	0	1	0
3. Lis model	1	0	1	0
4. O. P. Zaitseva model	1	0	0	1
5. R. S. Sayfullin and G. G. Kadykov model	1	0	1	0
6. V. V. Kovalev model	1	0	1	0
Term weights	1	0	5/6	1/6
Total values	$g_2(2016) = 0.26 * 1 + 0.74 * 0 = 0.26$		$g_2(2017) = 0.26 * 5/6 + 0.74 * 1/6 = 0.34$	
Integrated value	$g_2 = g_2(2016) * 1/3 + g_2(2017) * 2/3 = 0.26 * 1/3 + 0.34 * 2/3 = 0.31$			

Source Developed by the authors

Table 4 The aggregation of BR estimates based on MDA models distinguishing three states (G1/"BR low"; G1/"BR low"; G1/"BR high")

Model	2016			2017		
	G1	G2	G3	G1	G2	G3
1. Altman two-factor model	1	0	0	1	0	0
2. Modified five-factor Altman model	1	0	0	0	1	0
3. Altman model for non-manufacturing companies	0	1	0	0	1	0
4. Altman model for emerging markets	1	0	0	1	0	0
5. Tuffler-Tishou model	1	0	0	1	0	0
Term weights	4/5	1/5	0	3/5	2/5	0
Total values for years	$g_3(2016) = 0.155 * 4/5 + 0.5 * 1/5 + 0.845 * 0 = 0.224$			$g_3(2017) = 0.155 * 3/5 + 0.5 * 2/5 + 0.845 * 0 = 0.293$		
Integrated value	$g_3 = g_3(2016) * 1/3 + g_3(2017) * 2/3 = 0.224 * 1/3 + 0.293 * 2/3 = 0.27$					

Source Developed by the authors

Table 5 The aggregation of BR estimates based on MDA models distinguishing five states (G1/"BR is very low"; G2/"BR is low"; G3/"BR is average"; G4/"BR is high"; G5/"BR is very high")

Model	2016					2017				
	G1	G2	G3	G4	G5	G1	G2	G3	G4	G5
1. ISEA model	1	0	0	0	0	1	0	0	0	0
2. Savitskaya model	0	1	0	0	0	0	0	1	0	0
Term weights	1/2	1/2	0	0	0	1/2	0	1/2	0	0
Total values for years	$g_5(2016) = 0.125 * 1/2 + 0.3 * 1/2 + 0.5 * 0 + 0.7 * 0 + 0.875 * 0 = 0.21$					$g_5(2017) = 0.125 * 1/2 + 0.3 * 0 + 0.5 * 1/2 + 0.7 * 0 + 0.875 * 0 = 0.31$				
Integrated value	$g_5 = g_5(2016) * 1/3 + g_5(2017) * 2/3 = 0.21 * 1/3 + 0.31 * 2/3 = 0.28$									

Source Developed by the authors

Table 6 Aggregating BR estimates from Tables 2, 3 and 4 to the final grade

BR Estimates	Terms		
	G1	G2	G3
$g1 = 0.31$	0.4	0.6	0
$g2 = 0.27$	0.65	0.35	0
$g3 = 0.28$	0.6	0.4	0
Term weights	0.55	0.45	0
Integrated BR value	$g = 0.155 * 0.55 + 0.5 * 0.45 + 0.845 * 0 = 0.31$		

Source Developed by the authors

corresponding term). The values of membership functions are: $\mu(0.31) = \mu_2(0.31) = 0.45$; $\mu(0.31) = \mu_1(0.31) = 0.55$. Thus, we can assume that the enterprise can be assigned to the first term ("BR low") with a probability of 0.45 and to the second term ("BR medium") with a probability of 0.55.

Therefore, the analysis of the financial condition of the enterprise on the basis of thirteen different models allowed us to calculate the aggregate value, which gives an assessment of the risk of bankruptcy in the interval [0; 1]. Conventionally, this value can be considered as the risk of bankruptcy of the enterprise, calculated taking into account the views of thirteen independent experts.

5 Conclusion

A technique was developed, whose novelty is in the ability to aggregate the results of an analysis of the enterprise bankruptcy risk obtained as a result of applying a complex of various bankruptcy models. At the same time, models can use various criteria and classify the state of the enterprise in different ways. As follows from the description of the methodology, the complex of the used models may vary depending on the objectives of the study.

References

1. Altman, E.I.: Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. J. Financ. **4**, 589–609 (1968)
2. Altman, E.I.: Further empirical investigation of the bankruptcy cost question. J. Financ. **39**(4), 1067–1089 (1984)
3. Davydova, G.V., Belikov, A.Y.: Methods of quantitative assessment of bankruptcy risk of enterprises. Risk Manag. **3**, 13–20 (1999)
4. Deakin, E.: Discriminant analysis of predictors of business failure. J. Account. Res. **10**, 167–179 (1972)
5. Fedorova, E., Gilenko, E., Dovzhenko, S.: Bankruptcy prediction for Russian companies: Application of combined classifiers. Expert Syst. Appl. **18**(40), 7285–7293 (2013)

6. Fulmer Model: Retrieved from https://1-fin.ru/?id=281&t=1176 (1984)
7. Hajiha, Z.: Effective factors on alignment of accounting information systems in manufacturingcompanies: evidence from Iran. Inf. Manage. Bus. Rev. **3**(3), 158–170 (2011)
8. Kochenev, Y.Y., Lukashevich, N.S.: The assessment of audit risk based on fuzzy logic. Nauchno-tekhnicheskie Vedomosti St. Petersburg state Polytechnial University. Economics **6**, 248–253 (2011)
9. Lis Model: Retrieved from https://1-fin.ru/?id=281&t=967 (1972)
10. Nedosekin, A.O.: Fuzzy Financial Management. AFA Library, Moscow (2003)
11. Nedosekin, A.O., Kozlovsky, A.N., Abdulaeva, Z.I.: The analysis of branch economic stability by fuzzy-logical methods. Econ. Manag.: Probl., Solut. **5**, 10–16 (2018)
12. Nedosekin AO (2000) Application of the fuzzy sets to the problems of financial management. Audit and Financial Analysis, 2. Retrieved from https://www.cfin.ru/press/afa/2000-2/08.shtml
13. Saifullin Model: Retrieved from https://1-fin.ru/?id=281&t=1164 (1996)
14. Springite Model: Retrieved from https://1-fin.ru/?id=281&t=1572 (1978)
15. Taffler, R.J.: The assessment of company solvency and performance using a statistical modeling. Account. Bus. Res. **13**(52), 295–307 (1983)
16. Taffler, R.J., Tisshaw, H.J.: Going Going gone four factors which predict. Accountacy **88**, 50–54 (1977)
17. Yakimova, V.A.: Optimization of audit actions on the basis of an assessment of sufficiency of auditor proofs and labor input of process of their collecting. Int. Account. **43**, 25–36 (2012)
18. Zade, L.A.: Concept of a Linguistic Variable and Its Application to Making Approximate Decisions. Mir, USSR, Moscow (1976)
19. Zaitseva, O.P.: Crisis management in Russian company. Aval **11–12**, 66–73 (1998)

Fuzzy-Multiple Analysis of Financial Statements of Enterprises

Lyudmila V. Sakharova, Anatoly F. Chuvenkov, and Michael Yu. Denisov

Abstract The aim of the paper is to develop a methodology for assessing the financial condition of an enterprise based on a fuzzy-multiple modification of the Audit-IT integrated scoring methodology. The modification was carried out using the approach developed by O. A. Nedosekin to assess the risk of bankruptcy of the enterprise and consisting in the aggregation of indicators of coefficient analysis using standard five-point classifiers. Based on the developed methodology, the estimates of the financial condition and performance, as well as the integral assessment (score) of the financial condition of the enterprise for three years, were calculated. The correspondence of the calculated estimates to the results obtained using Audit-IT was revealed. At the next step, the technique is modified by including additional parameters in the complex and dividing it into four blocks: (1) financial soundness; (2) liquidity; (3) profitability; (4) business activity. An integrated assessment for each of the blocks was found by aggregating indicators calculated by the "Your Financial Analyst" program. The final assessment of the financial and economic condition of the enterprise is formed by aggregating four integral estimates based on standard five-point classifiers. Calculation of relevant estimates allows for intra-industry ranking of enterprises, as well as their clustering, followed by a study of the correlation dependencies between indicators of financial and economic activity within clusters. The proposed methodology demonstrates the possibility of transforming the standard integrated scoring methodology for assessing the financial condition of an enterprise into the corresponding fuzzy-plural technique, which has a number of important advantages. In particular, it allows to change the complex of the studied parameters depending on the goals and objectives of the study without significant processing of the model; to adjust the weight of the parameters depending on the industry and territorial specifics, as well

L. V. Sakharova (✉) · A. F. Chuvenkov · M. Yu. Denisov
Rostov State University of Economics, Rostov-on-Don, Russia
e-mail: L_Sakharova@mail.ru

A. F. Chuvenkov
e-mail: chuvenkovaf@mail.ru

M. Yu. Denisov
e-mail: lunatik1957@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_12

as to conduct expert assessments; as well as to bring together quantitative estimates of indicators with estimates of the dynamics of their change.

Keywords Financial statement analysis · Comprehensive assessment · Aggregation · Fuzzy-plural technique

1 Introduction

The primary link in the economy is the enterprise. "The combination of enterprises forms the basis of a multi-level pyramid, on top of which are the state bodies that shape the country's budget, tax policy, and the program for the development of the national economy" [1]. Therefore, the methods of analysis of the financial and economic activities of the enterprise represent the basis of the theoretical research tools and management practices of both the country's economy as a whole and its sectors [2].

As an analysis tool, financial ratios are most often used to identify both the dynamics of indicators and the limits of permissible values (restrictions) and ratios of indicators. The criteria are developed on the basis of which the coefficients give a qualitative assessment of the financial condition of the organization, most often on the basis of integral scores [3]. Integral assessment of financial condition is of great importance for government bodies that shape investment and tax policies, potential investors, and partners of the company, as well as managers of the company. The method of integrated estimates takes into account all the relationships between the indicators and also allows accurately tracking the possible dynamics and identifying deviations [4].

The main disadvantages of the methods based on integrated assessments are the subjective approach to determining expert assessments and ignoring the specific features of the enterprise and industries [5]. Scoring is automatic, most indicators have equal or arbitrary weight; when adding new indicators, one has to change the entire order of the account, etc. These models are difficult to modify; a significant problem is the consideration of expert opinions, as well as the uncertainty of external conditions.

At the same time, fuzzy logic is beginning to penetrate into financial analysis, a relatively young toolbox of mathematical modeling in conditions of complete uncertainty, that is, in conditions of probabilistic variability of the external environment and the uncertainty of expert estimates. The model of enterprise bankruptcy risk assessment based on the standard five-point [0, 1] classifiers developed by Nedosekin is widely known [6]. The model was generalized to a set of indicators that go beyond the scope of financial reporting and are taken into account in Argenti's quantitative point scale [7]. In addition to the traditional block of the finance level, the author considered the enterprise management block, which includes the level of top management, financial management, marketing and advertising divisions, and the development of the distribution network and branches. The model showed a high level of prediction accuracy, flexibility, and modifiability. Its novelty consists in its ability to aggregate for the assessment of a large number of heterogeneous indicators (up to high-quality insider information); simultaneously, the assessment factors form a tree hierarchy, and the factors of one hierarchical sublevel are preferential/indifferent to each other. The applied approach indicates the way to build similar fuzzy-logical models, based on generally accepted integrated score models for assessing the financial condition of an enterprise.

This paper focuses on a fuzzy-multiple modification of "Methods of analysis of the financial condition of the organization" of Audit-IT [10]. In order to implement the methodology, we used proprietary methods for assessing the state of systems, based on the fuzzy-multiple aggregation of indicator complexes [8, 9].

2 Materials and Methods

In accordance with the "Audit-IT Methodology for Analysis of the Financial State of Organizations," the analysis of financial conditions is carried out, according to the accounting (financial) statements of organizations (Form No. 1 "Balance Sheet" and No. 2 "Statement of Financial Results") ("Profit and Loss Statement"). For the purposes of a qualitative assessment of financial indicators, a scale of five main gradations is used (Table 1).

The numerical intervals of indicators corresponding to each qualitative value are established on the basis of expert estimates and reflect the standards adopted for a particular industry. At the same time, the intervals of values "excellent," "good," "satisfactory," "unsatisfactory," and "critical" are set.

Summarizing (integral) assessment of the financial condition of the organization consists of an assessment of the financial situation and assessment of the effectiveness of the organization (Table 2).

Table 1 The gradations scale "Methods of analysis of the financial condition of organizations"

Code	Indicator value	Description of quality characteristics
2	Excellent	Excellent, exceptionally good indicator
1	Good	Good, positive indicator value; fully compliant value
0	Satisfactory	The indicator is relevant in the region of the border of the norm; formally may not meet the norm, but deviation from the norm is not significant
−1	Unsatisfactory	Unsatisfactory, negative indicator values; the value of the indicator does not meet the norm
−2	Critical	The critical value of the indicator; the value of the indicator is much worse than the norm

Source Audit-IT [10]

Table 2 The gradations scale of a generalizing assessment “Methods of analysis of the financial condition of organizations”

Score		Designation (rating)	Qualitative characteristic of financial condition
From	To		
2	1.6	AAA	Excellent
1.6	1.2	AA	Very good
1.2	0.8	A	Good
0.8	0.4	BBB	Positive
0.4	0	BB	Normal
0	−0.4	B	Satisfactory
−0.4	−0.8	CCC	Unsatisfactory
−0.8	−1.2	CC	Bad
−1.2	−1.6	C	Very bad
−1.6	2	D	Critical

Source Audit-IT [10]

The following indicators are involved in the generalized assessment of the financial condition (the weight of the indicator is given in parentheses): autonomy coefficient (0.25); ratio of net assets and authorized capital (0.1); the ratio of own working capital (0.15); current (total) liquidity ratio (0.15); quick (interim) liquidity ratio (0.2); absolute liquidity ratio (0.15).

The following indicators are involved in a generalized assessment of performance: return on equity (0.3); return on assets (0.2); return on sales (0.2); revenue dynamics (0.1); working capital turnover (0.1); the ratio of profit from other operations and revenue from core activities (0.1).

Based on the points of the financial position and performance, a generalized score, the financial position score, is calculated. This score is obtained as the sum of the financial position score multiplied by 0.6, and the financial result score multiplied by 0.4. That is, the indicators are taken in the proportions of 60% and 40%, respectively, since the indicator of the financial situation, to a greater extent, characterizes the financial condition of the organization.

Depending on the value of the financial condition score (in accordance with the table above), the organization is assigned one of ten values of the financial rating—from AAA (the best) to D (the worst).

Thus, in the process of analysis, the financial position analysis unit breaks down into four blocks: (1) the structure of the property and sources of its formation (12 indicators); (2) the assessment of the value of the net assets of the organization (3 indicators); (3) the analysis of the financial stability of the organization (13 indicators); (4) the analysis of the liquidity (7 indicators).

The analysis of the effectiveness of the organization includes: (1) a review of the results of the organization (10 indicators); (2) the analysis of profitability (10 indicators); (3) the calculation of indicators of business activity (turnover) (6 indicators).

However, in order to construct an integrated assessment for each of the two blocks, only six key indicators are used, which is apparently due to the inefficiency of the proposed aggregation algorithm for a large number of parameters. Since scores of indicators can be both positive and negative, when summing into the final assessment, the terms of opposite signs can cancel each other out. As a result, significant deviations from the two parameters in the direction of "critical" and "excellent" states can lead to a final rating of "satisfactory". When aggregating a large number of parameters, some uninformative "average value" of the integral estimate can be obtained.

It should also be noted that the methodology includes too many classes (10 pieces), which makes the results difficult to observe.

As an alternative, we proposed a methodology for calculating the integral estimate based on the aggregation of parameter values through a system of fuzzy-logical conclusions—standard five-level [0, 1] classifiers.

The construction of the methodology was carried out in two stages. The source material was an analysis of the financial situation and performance of OAO Zarya for the period from January 1, 2016, to December 31, 2018 (3 years), conducted according to the Audit-IT Methodology for Analysis of the Financial State of Organizations with the Your Financial Analyst software.

At the first stage, estimates of the financial condition and effectiveness of the enterprise, as well as a generalized assessment (financial condition score), were calculated on the basis of sets of parameters that coincided with what was used in Audit-IT, "Analysis of the financial condition of organizations". The results are compared.

In the second stage, a methodology was developed for calculating complex assessments of the financial and economic activities of the enterprise in four blocks: (1) financial stability, (2) liquidity, (3) profitability, and (4) business activity. Each assessment is calculated on the basis of a set of indicators calculated on the basis of the balance sheet data and appearing in the Audit-IT analytical report.

When calculating a comprehensive assessment based on a set of indicators, two main problems arise: the aggregation of time series into numerical values of indicators and the assessment of numerical values of indicators and their aggregation into a comprehensive assessment.

For most of the parameters used to build the financial condition score, qualitative estimates are known, including by industry (given in "Audit-IT Methodology for Analysis of the Financial State of Organizations"). In this case, the aggregation of time series of values for N years can be performed based on the following formula [8, 9]:

$$x_i = \sum_{i=1}^{N} k_i P_i, \quad k_i = \frac{2(N+1-i)}{(N+1)N}$$

where P_i = the parameter values by years and k_i = weighting coefficients determined according to the Fishburn rule, taking into account the "weight" of years, and the numbering of years is in reverse order.

If there are no qualitative estimates of the parameters and the dynamics of their change is fundamental, then a simplified aggregation scheme is used. The dynamics of indicators for the considered period of N years is taken into account on the basis of the scheme:

$$x_i = 0.5\left(1 + \sum_{i=1}^{N-1} k_i I_i\right), \quad k_i = \frac{2(N-i)}{(N-1)N},$$

where k_i = weight coefficients determined by the Fishburne rule and time periods are numbered in reverse order; I_i = integer functions defined in such a way that the value 1 corresponds to an increase in the ith indicator (deterioration of the situation), the value -1 = a decrease in the ith indicator, and the value 0 = stabilization, no change.

It is proposed to aggregate indicators into a comprehensive assessment based on standard five-level [0, 1] classifiers. Each indicator is associated with a linguistic variable term. Their set consists of five terms: G = {G1, G2, G3, G4, G5}: G1 = condition, G2 = unsatisfactory condition, G3 = satisfactory condition; G4 = good condition, and G5 = excellent condition. Each linguistic variable has a trapezoidal membership function that can be determined by four numbers (a1, a2, a3, a4). For each of the indicators, in accordance with the intervals of the qualitative assessment given in the "Audit-IT Methods of Analysis of the Financial Condition of Organizations", the corresponding quadruples of numbers obtained by fuzzification of the initial intervals are given.

The final linguistic variables (assessments of the financial condition, assessment of the company's activity, etc.) are also evaluated on the basis of standard five-level fuzzy [0, 1]—classifiers. The membership functions of the terms, in this case, are symmetrical and are determined by the formulas listed in Table 3.

The numerical values of the resulting linguistic variables belonging to the interval [0, 1] are calculated by aggregating parameter complexes based on the standard scheme. To formulate the rule of transition from indicators xi to linguistic variables, weights of indicators and their relative importance coefficients are taken into account—k_i, $i = 1, \ldots, N$. With the chosen system of indicator weights according to the theory of fuzzy sets, the rule of transition from the values of the indicators xi to the weights of the terms of the linguistic variable g has the form:

$$p_j = \sum_{i=1}^{N} k_i \mu_{ji}, \quad j = 1, 2, 3, 4, 5,$$

where μ_{ji}—the value of membership functions of terms. The value of the numerical variable g itself is based on the formula:

Table 3 The membership functions of the subsets of the term set G for the final estimates of the author's fuzzy-plural technique

Term Gi	Fuzzy set membership function Gi
G1	$\mu_1 = \begin{cases} 1, & 0 \le g < 0.15 \\ 10(0.25 - g), & 0.15 \le g < 0.25 \end{cases}$
G2	$\mu_2 = \begin{cases} 1 - 10(0.25 - g), & 0.15 \le g < 0.25 \\ 1, & 0.25 \le g < 0.35 \\ 10(0.45 - g), & 0.35 \le g < 0.45 \end{cases}$
G3	$\mu_3 = \begin{cases} 1 - 10(0.45 - g), & 0.35 \le g < 0.45 \\ 1, & 0.45 \le g < 0.55 \\ 10(0.65 - g), & 0.55 \le g < 0.65 \end{cases}$
G4	$\mu_4 = \begin{cases} 1 - 10(0.65 - g), & 0.55 \le g < 0.65 \\ 1, & 0.65 \le g < 0.75 \\ 10(0.85 - g), & 0.75 \le g < 0.85 \end{cases}$
G5	$\mu_5 = \begin{cases} 1 - 10(0.85 - g), & 0.75 \le g < 0.85 \\ 1, & 0.85 \le g \le 1 \end{cases}$

$$g = \sum_{j=1}^{5} p_j \cdot \overline{g}_j,$$

where $\overline{g}_j$—the middle of the interval is the carrier of the term $G_j \in \left(a_{j1},\ a_{j5}\right]$. After that, linguistic recognition of the obtained numerical value is carried out on the basis of the term set introduced earlier, G = {G1, G2, G3, G4, G5}.

Source Alekseychik et al. [8].

3 Results

The activities of OAO Zarya are attributed to the Crude Oil and Natural Gas Production sector (class NACE—6), which was taken into account in the qualitative assessment of financial indicators.

1st stage—Table 4 shows the calculation of the weights of the terms of a generalized assessment of the financial condition for the indicators used in the "Audit-IT Methodology for Analysis of the Financial State of Organizations."

Table 4 Calculation of a generalized assessment of financial condition using a fuzzy-multiple technique for a set of indicators used in Audit-IT

Indicator	Nodal points		0.125	0.3	0.5	0.7	0.885
	Weights	x_i	G1	G2	G3	G4	G5
Autonomy ratio, x_1	0.25	0.512	0	1	0	0	0
The ratio of net assets and authorized capital, x_2	0.1	1	0	0	0	0	1
The ratio of own working capital, x_3	0.15	−0.658	1	0	0	0	0
Current (total) liquidity ratio, x_4	0.15	0.865	1	0	0	0	0
Quick (interim) liquidity ratio, x_5	0.2	0.817	0	0	1	0	0
Absolute liquidity ratio, x_6	0.5	0.175	1	0	0	0	0
Term weights	1		0.45	0.25	0.2	0	0.1

Source Developed by the authors

The assessment of the financial condition:

$$\begin{aligned} G = {} & 0.125 * 0.45 + 0.3 * 0.25 + 0.5 * 0.2 + 0.7 * 0 \\ & + 0.885 * 0.1 = 0.32(\text{G2, “bad”}). \end{aligned}$$

Similarly, the assessment of the efficiency of the enterprise was obtained: 0.85 (G5, “excellent”).

Finally, by aggregating the assessments of the financial condition and performance of the enterprise on the basis of standard five-level fuzzy [0, 1] classifiers, an integral score of the financial and economic activity of the enterprise was obtained: 0.53 (G3, “satisfactory”).

The presented results are confirmed by the conclusions made on the basis of the software “Your Financial Analyst”, which implements the Audit-IT methodology.

2nd stage—Four integral estimates of the enterprise are calculated: stability, liquidity, profitability, and turnover. The calculation of a generalized assessment of the sustainability of the enterprise is presented in Table 5.

$$\begin{aligned} & G = 0.125 * 0.45 + 0.3 * 0.45 + 0.5 * 0 + 0.7 * 0 + 0.885 * 0.2 = 0.37; \\ & \mu 2(0.37) = 0.8;\ \mu 3(0.37) = 0.2(\text{G2, “bad”}). \end{aligned}$$

Similarly, a generalized assessment of the liquidity of the enterprise is calculated based on the aggregation of three standard ratios (current, quick, and absolute liquidity). It is equal to 0.25, which corresponds to the term G2, “bad”. A general assessment of the profitability of the enterprise is calculated on the basis of aggregation of six

Table 5 The calculation of a generalized assessment of the stability of the enterprise using a fuzzy-plural technique

Indicator	Nodal points		0.125	0.3	0.5	0.7	0.885
	Weights	x_i	G1	G2	G3	G4	G5
The ratio of autonomy	0.25	0.512	0	1	0	0	0
The ratio of financial leverage	0.1	0.976	0	1	0	0	0
The ratio of own working capital	0.15	−0.658	1	0	0	0	0
The ratio of investment coverage	0.1	0.606	0	1	0	0	
The ratio of equity maneuverability	0.1	−0.355	1	0	0	0	0
The ratio of reserves	0.1	−1740.428	1	0	0	0	0
Net assets	0.1	1	0	0	0	0	1
The excess of net assets over authorized capital	0.1	1	0	0	0	0	1
Term weights			0.45	0.45	0	0	0/2

Source: Calculated by the authors

indicators (return on sales, return on sales by net profit, return on assets, return on equity, and revenue dynamics) and is equal to 0.87, which corresponds to the term G5, "excellent". Finally, a generalized assessment of the business activity (turnover) of the enterprise is built on the basis of aggregation of four indicators (turnover of current assets, stocks, receivables, and equity) and is 0.69, which corresponds to G4, "good".

Based on the above, an aggregate assessment of the financial and economic activity of the enterprise is built; it is equal to 0.51, which corresponds to the term G3, "satisfactory".

4 Discussion

Thus, the proposed fuzzy-plural technique, on the one hand, is consistent with the Audit-IT scoring methodology for analyzing the financial condition of organizations, on the basis of which it is built. On the other hand, it offers such an important advantage in terms of variability (i.e., the ability to enter a review of additional parameters; change their weights in accordance with the objectives of the study and expert estimates; to supplement the assessment complex with new blocks without additional "adjustment" of the methodology for the changes being introduced).

In addition, the proposed methodology, unlike standard methods, allows us to use for the formation of a comprehensive assessment not only the magnitude of the studied parameters but also the dynamics of their change. As a result, each enterprise can be assigned a vector of assessments (g1, g2, g3, g4), which can be supplemented and expanded, depending on the objectives of the study, by studying additional indicators like the number of employees, tax burden, relative volumes of state support and investment, etc. As a result, it is possible to create a basis for the clustering of enterprises within one industry with the subsequent study of the dependencies between the characteristics of the enterprise.

5 Conclusion

A methodology has been developed that demonstrates the process of modifying the standard integrated score model for assessing the financial condition of an enterprise based on a system of fuzzy-logical conclusions—fuzzy five-level [0, 1]—classifiers. Compared with standard methods, the fuzzy-multiple methodology for analyzing financial statements has a number of new features, which allow us to change the set of studied parameters depending on the goals and objectives of the study without significant revision of the model; adjust the weight of the parameters depending on the industry and territorial specifics, as well as expert assessments; and to bring together quantitative estimates of indicators with estimates of the dynamics of their change.

References

1. Artyukhova, A.V., Litvin, A.A.: The analysis of the financial condition of the company: the essence and the need for. Young Sci. **11**, 744–747 (2015)
2. Fursova, M.N., Ilin, A.A., Moiseeva, L.V.: Business Analysis: Study Guide. Publishing House of VSUES, Voronezh, Russia (2011)
3. Khriplivy, F.P., Khriplivy, A.F.: Comparative analysis of methods for assessing the financial condition of an organization. Polythematic Netw. Electron. Sci. J. Kuban State Agrarian Univ. **81**, 22 (2012)
4. Kuvshinov, M.S.: Innovative forecasting tools for assessing the financial condition of the company. Bull. South Ural State Univ. Ser. Econ. Manag. **30**, 56 (2012)
5. Smelova, T.A., Merzlikina, G.S.: Assessment of Economic Solvency in Crisis Management of an Enterprise. VolgSTU, Volgograd, Russia (2003)
6. Nedosekin, A.O.: Fuzzy Financial Management. AFA Library, Moscow, Russia (2003)
7. Nedosekin, A.O.: Business risk assessment based on fuzzy data (Monograph). St Petersburg, Russia (2005)

8. Alekseychik, T.V., Bogachev, T.V., Karasev, D.N., Sakharova, L.V., Stryukov, M.B.: Fuzzy method of assessing the intensity of agricultural production on a set of criteria of the level of intensification and the level of economic efficiency of intensification. Adv. Intell. Syst. Comput. **896**, 790–798 (2019)
9. Vovchenko, N.G., Stryukov, M.B., Sakharova, L.V., Domokur, O.V.: Fuzzy-logic analysis of the state of the atmosphere in large cities of the industrial region on the example of Rostov region. Adv. Intell. Syst. Comput. **896**, 709–715 (2019)
10. Audit-IT: The Financial Analysis. Retrieved from https://www.audit-it.ru (2019).

Aggregation of Enterprise Bankruptcy Risk Assessments Based on Logit Complex—Mamdani Models and Fuzzy Logic Inference

Lyudmila V. Sakharova, Sergey V. Rogozhin, and Alexander N. Kuzminov

Abstract The problem of increasing the predictive accuracy of bankruptcy forecasting in the analysis of data arrays of various nature is considered. The analysis of existing approaches showed their limitations. The goal of the study is to develop a methodology that allows to aggregate estimates of the bankruptcy risk of an enterprise, obtained on the basis of a combination of logit models. The proposed approach is based on the results of the Mamdani fuzzy-logical conclusion and, when constructing complex estimates, possesses such properties as variability, the ability to quickly adapt to a specific task by varying weight coefficients, ease of implementation, and wide possibilities for taking into account expert opinions in the model. The adjustment of the model for industry and time specifics is carried out not by recalculating the coefficients in the original logit—models, but by clarifying the weighting coefficients of the models, based on expert estimates and recommendations. The aggregation of enterprise bankruptcy risk assessments obtained on the basis of five different models (Altman-Sabato, Lina-Pesse, Gruzczynski, JuHa-Tehong, and Zhdanov) was carried out; the initial estimates are characterized by different quantities, opposite dynamics, and do not allow an unambiguous interpretation by conventional methods. The aggregated estimates are constructed over the five considered years, taking into account the significance of the models used. The proposed model is new in the view of developing fuzzy-multiple methods of complex estimates for the analysis of financial statements.

Keywords Integrated assessment · Aggregation · Fuzzy-plural technique

L. V. Sakharova (✉) · S. V. Rogozhin · A. N. Kuzminov
Rostov State University of Economics, Rostov-on-Don, Russia
e-mail: L_Sakharova@mail.ru

S. V. Rogozhin
e-mail: sergeyvr@yandex.ru

A. N. Kuzminov
e-mail: akuzminov@sfedu.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_13

1 Introduction

The study of prevailing bankruptcy forecasting methods in scientific practice demonstrates the commonality of the disadvantages of MDA modeling [1, 2], which is constructed using discriminant analysis—due to the impossibility of an adequate assessment of the qualitative characteristics of the probable state of bankruptcy.

Also, in all MDA models, there is a so-called "zone of uncertainty" [3], when a calculated final indicator falls into it, it is impossible to draw an unambiguous conclusion about the probability of bankruptcy. Consequently, more modern econometric tools are increasingly used in international practice. First, logit models are constructed with the help of a logistic regression apparatus [4, 5].

The logistic regression acts as a statistical model used to calculate the probability of a random event—the bankruptcy of an enterprise on the basis of the numerical values of a set of features. To assess the probability of bankruptcy, the so-called dependent variable Y is introduced, taking either (a) one of two values of "0–1" ("bankruptcy has occurred; bankruptcy has not occurred") or (b) some value from the interval [0, 1] (numerical value probability of occurrence of bankruptcy). In addition, a set of independent real variables (x1, x2, …, xn) called signs, predictors, or regressors, is introduced. The task is to calculate, based on the numerical values of the predictors, the probability of a possible bankruptcy of the enterprise.

Logit models for bankruptcy forecasting are of significant interest to scientists and analysts, since, firstly, they show high levels of consistency in qualitative and empirical research. Secondly, in contrast to discriminant models that can only determine the qualitative degree of probability of bankruptcy, there are no problems in logit models with an unambiguous interpretation of the resulting indicator of this probability. Thirdly, in the logit models, there are no "zones of uncertainty," which are inherent in discriminant models. If a certain probability of bankruptcy takes a numerical value higher than 0.5, then a prediction that the event will occur is usually made. If it is less than or equal to this number, then it is predicted that the event will not occur. It should be noted that this cut-off threshold does not pretend to be universal: an expert analyzing a company has the right to subjectively determine the numerical characteristics of this threshold.

At the same time, despite the positive factors of using logistic regression and the logit models based on it to assess the probability of bankruptcy of enterprises, these models also have a number of disadvantages.

Firstly, based on the analysis of Russian companies' risk of bankruptcy, a variety of logit models often give different, even opposite, results, which impedes a high-quality diagnosis and the formation of an adequate forecast. The used models can be ranked in the order of their reliability or applicability in a sectoral or territorial-temporal context. However, the number of such studies is very small, and there are no universal ranking methods [6].

Secondly, even with a satisfactory ranking of logit models, it seems difficult to generalize the results obtained on the basis of several models. The problem can be solved by constructing integrated point methods. However, they will have all the disadvantages inherent in the spectrum-point models: unreasonable point accrual, lack of weight variability, and the need to redo the model every time according to the changing study tasks and expert opinions [7].

As a solution to the problem, the idea of hybridization can be used [8], for example, by combining the one proposed in this paper with fuzzy multiple techniques for constructing integrated assessments of an enterprise's bankruptcy risk based on estimates of a set of logit models. Systems of fuzzy-logical conclusions are the preferred mathematical tools for constructing complex assessments since they have high variability, the ability to adapt quickly to a specific task by varying the weight coefficients, ease of implementation, and wide possibilities for taking expert opinions in the model into account.

2 Materials and Methods

In each logit model, the probability of bankruptcy is calculated using the standard formula of the logistic function, which has the form, where p is the probability of bankruptcy and Y is an integral indicator depending on the model. Table 1 shows the most famous foreign logit models for assessing the probability of bankruptcy. There are also domestic developments, such as the logit model of Zhdanov & Afanasyeva [9], which has the form $p = (1 + \exp(-y))^{-1}$,

$$Y = 4.32 - 1.25X_1 - 0.12X_2 - 0.07X_3 - 0.34X_4 - 2.17X_5$$

where p is the probability of bankruptcy, Y is the linear combination of independent variables, X_1 is the return on current assets, X_2 is the self-financing ratio, X_3 is the ratio of mobile and immobilized assets, X_4 is the asset turnover ratio, and X_5 is the current liquidity ratio.

In Table 1, the following generally accepted designations are used [18]:

SIZE—the size of the enterprise, calculated as the natural logarithm of the ratio of the total assets of the enterprise to the deflator (growth rate) of GDP. TLTA—the leverage ratio, calculated as the ratio of total debt to total assets. WCTA—the share of working capital, calculated as the ratio of networking capital to total assets. CLCA—the ratio of current liabilities to current assets. NITA—the return on assets (referring to economic profitability), calculated as the ratio of net profit from all types of activities to the average annual value of assets. FUTL—the ratio of net working capital (funds created at the enterprise) to total debt. INTWO—a dummy variable assuming a value of 1 if the net income of the enterprise over the past two years is a negative value (the company worked at a loss) and equal to 0 if the value is different. OENEG—another dummy variable, assuming a value of 1 if the current debt of the enterprise exceeds its current assets, and a value of 0 if not. CHIN—the measure of changes in net income (net profit) over the past two years. F/OWKSA—the ratio of financial working capital to revenue. FINLEV—the financial leverage. INTCOV—the coverage ratio. OWKSA—the ratio of own working capital to revenue.

Table 1 A summary table of the mostly known and widely used logit models for bankruptcy forecasting

The authors of the model (year of model creation)	Country and number of analyzed resident companies (for the period, years)	The formula for calculating the integral indicator
Ohlson [10]	USA, 2163 (1970–1976)	$Y = -1.32 - 0.407 \times \text{SIZE} - 6.03 \times \text{TLTA} - 1.43 \times \text{WCTA} + 0.0757 \times \text{CLCA} - 2.37 \times \text{NITA} - 1.83 \times \text{FUTL} + 0.285 \times \text{INTWO} - 1.72 \times \text{OENEG} - 0.521 \times \text{CHIN}$
Begley et al. [11]	USA	$Y = -1.249 - 0.211 \times \text{SIZE} - 2.262 \times \text{TLTA} - 3.451 \times \text{WCTA} - 0.293 \times \text{CLCA} - 0.907 \times \text{OENEG} + 1.080 \times \text{NITA} - 0.838 \times \text{FUTL} + 1.266 \times \text{INTWO} - 0.960 \times \text{CHIN}$
Joo-Ha and Taehong [12]	South Korea, 46 (1997–1999)	$Y = 0.1062 \times \text{INT/TR} - 0.00682 \times \text{EBIT/TL} - 0.1139 \times \text{TR/REC}$
Ginoglou and Agorastos [13]	Greece, 40 (1981–1985)	$Y = -0.138 + 16.555 \times \text{NP/AT} + 3.54 \times \text{GP/AT} + 0.002 \times \text{TL/EQ} + 0.789 \times (\text{AC} - \text{SL})/\text{AT}$
Gruszczynski [14]	Poland, 46 (1995)	$Y = 1.3508 + 7.5153 \times \text{OP/AT} - 6.1903 \times \text{TL/AT}$
Lin and Piesse [15]	UK, 77 (1985–1995)	$Y = -0.2 - 0.33 \times \text{NP/AT} - 0.17 \times \text{CASH/TL} - 0.95 \times (\text{AC} - \text{SL})/\text{AT}$
Altman and Sabato [16]	USA, 432 (2003–2004)	$Y = 4.28 + 0.18 \times \text{EBIT/AT} - 0.01 \times \text{SL/EQ} + 0.08 \times \text{NP/AT} + 0.02 \times \text{CASH/AT} + 0.19 \times \text{EBIT/INT}$
Minussi et al. [17]	Brazil, 6059 (2004–2005)	$Y = -5.76 - 2.53 \times \text{F/OWKSA} + 0.48 \times \text{FINLEV} - 0.17 \times \text{INTCOV} - 1.02 \times \text{OWKSA} + 0.63 \times \text{NWKSA}$

Source Muradov [18]

NWKSA—the ratio of working capital needs to revenue. AC—current assets. AT—total assets. TL—total liabilities. SL—short-term liabilities. LL—long term duties. EQ—capital and reserves. REC—accounts receivable (payments up to 12 months). TR—sales revenue. NP—net profit. GP—gross profit. SP—revenue from sales. OP—profit before tax. INT—payable interest. OC—operating costs. EBIT—profit before tax and interest. CASH—cash.

As already noted, the analysis of the same enterprise on the basis of several models often gives directly opposite, difficultly interpreted results. In Table 2, an analysis of the bankruptcy risk of an enterprise on the basis of financial statements using the QFinAnalysis program [19], and also on the curve (constructed using the same program) in Fig. 1 we can see a significant variation in the probability of bankruptcy.

The integral estimate obtained by us on the basis of the fuzzy-logical conclusion of Mamdani and presented in Fig. 1 is closer to reflecting the objectivity of the phenomenon, as it relies on the probabilistic nature of the input and output data.

Mamdani's fuzzy-logical conclusion is based on a fuzzy knowledge base:

$$\bigcup_{p=1}^{k_j}\left[\bigcap_{j=1}^{n} x_j = a_{i,jp} \text{ с весом } w_{jp}\right] \rightarrow y = d_j,\ j = 1,\ldots,m,$$

in which the values of the input and output variables are specified by fuzzy sets. Let $\mu_{jp}(x_j)$ be the membership function of the input of the fuzzy term $a_{i,jp}$, i.e.,

$$a_{i,jp} = \int_{\underline{x_j}}^{\overline{x_j}} \mu_{jp}(x_j)/x_j, \quad x_i \in \left\lfloor \underline{x}_j, \overline{x_j} \right\rfloor.$$

$\mu_{d_j}(y)$ membership function of the output fuzzy term d_j, i.e.,

$$d_j = \int_{\underline{y}}^{\overline{y}} \mu_{d_j}(y)/y, \quad y \in \left\lfloor \underline{y}, \overline{y} \right\rfloor.$$

The degrees of belonging of the input vector $X^* = \left(x_1^*, x_2^*, \ldots, x_n^*\right)$ to fuzzy terms from the knowledge base are calculated based on the formulas:

$$\mu_{d_j}\left(X^*\right) = \bigcup_{p=\overline{1,k_j}} w_{jp} \cdot \bigcap_{j=\overline{1,n}} \left[\mu_{jp}\left(x_i^*\right)\right], j = \overline{1, m},$$

where $\cup(\cap)$ is the implementation of the logical operations OR (AND). As a result, we obtain a fuzzy set, corresponding to the input vector X^*:

$$\tilde{y} = \frac{\mu_{d_1}(X^*)}{d_1} + \frac{\mu_{d_2}(X^*)}{d_2} + \cdots + \frac{\mu_{d_m}(X^*)}{d_m}.$$

A feature of this fuzzy set is that the universal set, for it is the term set of the output variable. Let us consider the implementation of the algorithm in the particular case when membership functions are given by fuzzy triangular numbers Table 3.

The weight coefficients of various models can be calculated in various ways. Firstly, to find them, the method of pairwise comparisons implemented by a group of

Table 2 The analysis of the bankruptcy risk of an enterprise based on financial statements using the QFinAnalysis program

Model	Year 1	Year 2	Year 3	Year 4	Year 5
Altman-Sabato model [16]					
X1 (profit before tax and interest/total assets)	−0.108	0.005	0.005	0.001	0.001
X2 (current liabilities/capital and reserves)	539,513	25,604	11,486	11,339	17,496
X3 (net profit/total assets)	−0.089	0.000	0.000	0.000	0.000
X4 (cash/total assets)	0.011	0.011	0.019	0.034	0.036
X5 (profit before tax and interest/interest payable)	−2.147	0.140	0.171	0.069	0.030
Z (integral indicator)	−1.549	4.052	4.199	4.181	4.112
P (probability of bankruptcy, %)	*18*	*98*	*98*	*98*	*98*
Lina-Pesse model [15]					
X1 (net profit/total assets)	−0.089	0.000	0.000	0.000	0.000
X2 (cash/total liabilities)	0.011	0.012	0.021	0.037	0.037
X3 [(current assets − current liabilities)/total assets]	−0.259	−0.138	−0.169	−0.064	0.419
Z (integral indicator)	0.473	0.329	0.357	0.254	−0.205
P (probability of bankruptcy, %)	*62*	*58*	*59*	*56*	*45*
JuHa-Tehong model [12]					
X1 (interest payable/sales revenue)	0.057	0.087	0.053	0.062	0.142
X2 (profit before tax and interest/total liabilities)	−0.108	0.005	0.006	0.001	0.001
X3 (sales revenue/receivables)	9.488	1.153	4.761	1.110	0.472
Z (integral indicator)	−1.081	−0.131	−0.542	−0.126	−0.054
P (probability of bankruptcy, %)	*25*	*47*	*37*	*47*	*49*
Gruzchinsky model (2003)					
X1 (profit before tax/total assets)	−0.108	0.005	0.005	0.001	0.001

(continued)

Table 2 (continued)

Model	Year 1	Year 2	Year 3	Year 4	Year 5
X2 (total liabilities/total assets)	0.998	0.962	0.921	0.923	0.971
Z (integral indicator)	−5.639	−4.569	−4.312	−4.355	−4.655
P (probability of bankruptcy, %)	*0*	*1*	*1*	*1*	*1*
Zhdanov & Afanasyeva model [9]					
X1 (return on current assets)	X	0.000	0.000	0.000	0.002
X2 (self-financing ratio)	X	25,635	11,732	12,041	33,731
X3 (ratio of mobile and immobilized assets)	X	4.649	2.744	4.149	11.966
X4 (asset turnover ratio)	X	0.538	0.594	0.398	0.297
X5 (current ratio)	X	0.480	0.679	0.603	0.977
Z (integral indicator)	X	−0.254	1.078	1.188	−2.660
P (probability of bankruptcy, %)	*X*	*44*	*74*	*76*	*7*

Source QFinAnalysis [19]

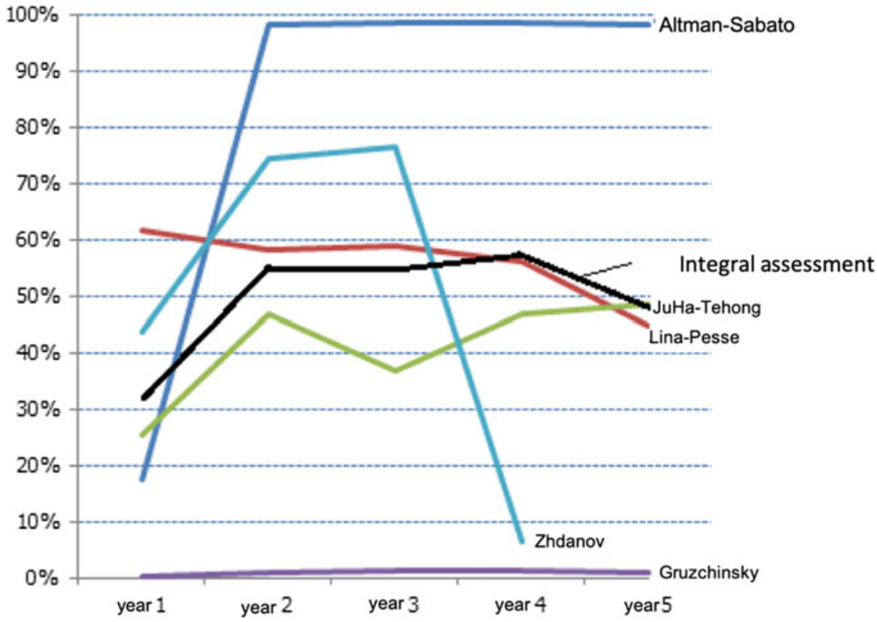

Fig. 1 The dynamics of enterprise bankruptcy risk assessments calculated on the basis of various logit models, based on QFinAnalysis [19]

Table 3 Membership functions of the subsets of the term set G for final estimates

Term d_j	Fuzzy set membership function G_i
d1—"The probability of bankruptcy is low"	$\mu_1 = -4(x - 0.25),\ 0 \le x < 0.15$
d2—"The probability of bankruptcy is below average"	$\mu_2 = \begin{cases} 4x, & 0 \le x < 0.25 \\ -4(x - 0.5), & 0.25 \le x < 0.5 \end{cases}$
d3—"The probability of bankruptcy is average"	$\mu_3 = \begin{cases} 4(x - 0.25), & 0.25 \le x < 0.5 \\ -4(x - 0.75), & 0.5 \le x < 0.75 \end{cases}$
d4—"The probability of bankruptcy is above average"	$\mu_4 = \begin{cases} 4(x - 0.5), & 0.5 \le x < 0.75 \\ -4(x - 1), & 0.75 \le x < 1 \end{cases}$
d5—"The probability of bankruptcy is high"	$\mu_5 = 4(x - 0.75), 0.75 \le x < 1$

Source Developed by the authors

experts for a given industry in a given time period can be used. Secondly, normalized frequencies of reliable predictions of the considered models in the studied area can be taken for the weighting coefficients. Thirdly, models can be ranked in the order of expert assessments of their reliability and applicability to a specific situation. In this case, weights can be calculated based on the Fishburn formula and its modifications, as is done below.

3 Results

Let us aggregate the data obtained using the QFinAnalysis program in the above example. We assume that the results of various models have a different level of reliability and that the numbering of the models increases in the direction of decreasing their significance. Then, the weighting coefficients of the models can be calculated, for example, based on a modified Fishburn formula. For 4 indicators, the formula $K_i = 0.1 + 0.6 * 2 * (N + 1 - i)/N * (N + 1)$, $N = 4$ is used for 5 indicators. The coefficients are calculated by the formula $K_i = 0.1 + 0.5 * 2 * (N + 1 - i)/N * (N + 1)$, $N = 5$. The process of aggregating data for the first year under review from Table 2 (four bankruptcy risk assessments) is shown in Table 4. The calculation is based on the fuzzy-logical conclusion of Mamdani.

The defuzzification of the constructed fuzzy set by the method of centers of gravity shows that $G = 1/12 * (1 * 0.2552 + 3 * 0.4648 + 6 * 0.1456 + 9 * 0.1344) = 0.311$. $\mu(0.31) = \mu 2(0.31) = 0.76$ (G2—“risk is lower than average”); $\mu(0.31) = \mu 3(0.31) = 0.24$ (G3—“medium risk”.)

Table 5 shows the results of aggregation of estimates for the second year (five models). Based on the calculations, it was found that $G = 1/12 * (1 * 0.16 + 3 * 0.063 + 6 * 0.436 + 9 * 0.096 + 11 * 0.245) = 0.544$. $\mu(0.54) = \mu 3(0.54) = 0.84$ (G3—“middle risk”), $\mu(0.54) = \mu 4(0.54) = 0.16$ (G4—“risk is above average”).

Table 4 The aggregation of bankruptcy risk estimates for the 1st year

Model	The probability of bankruptcy risk, x_j		The weight of the model, w_j	The values of membership functions of fuzzy terms d_j				
				d_1	d_2	d_3	d_4	d_5
Altman-Sabato model	x_1	0.18	0.34	0.28	0.72	0	0	0
Lina-Pesse model	x_2	0.62	0.28	0	0	0.52	0.48	0
JuHa-Tehong model	x_3	0.25	0.22	0	1	0	0	0
Gruzchinsky model	x_4	0	0.16	1	0	0	0	0
Degrees of belonging to fuzzy terms			1	0.2552	0.4648	0.1456	0.1344	0

Source Compiled by the authors

Table 5 The aggregation of bankruptcy risk estimates for year 2

Model name	Bankruptcy risk probability, x_j		Model weight, w_j	Values of membership functions of fuzzy terms d_j				
				d_1	d_2	d_3	d_4	d_5
Altman-Sabato model	x_1	0.98	8/30	0	0	0	0.08	0.92
Lina-Pesse model	x_2	0.58	7/30	0	0	0.68	0.32	0
JuHa-Tehong model	x_3	0.47	6/30	0	0.12	0.88	0	0
Gruzchinsky model	x_4	0.01	5/30	0.96	0.04	0	0	0
Zhdanov model	x_5	0.44	4/30	0	0.24	0.76	0	0
Degrees of belonging to fuzzy terms			1	0.16	0.063	0.436	0.096	0.245

Source Developed by the authors

Similarly, we get that the estimate for the third year is 0.554; $\mu(0.55) = \mu 3(0.55) = 0.8$ (G3—"middle risk"); $\mu(0.55) = \mu 4(0.55) = 0.2$ (G4—"risk is above average").

The estimate for the fourth year is 0.581; $\mu(0.58) = \mu 3(0.58) = 0.68$ (G3—"middle risk"); $\mu(0.58) = \mu 4(0.58) = 0.32$ (G4—"risk is above average").

Finally, the fifth year estimate is 0.476; $\mu(0.58) = \mu 2(0.48) = 0.08$ (G3—"risk is lower than average"); $\mu(0.58) = \mu 3(0.58) = 0.92$ (G4—"middle risk").

The obtained results are summarized in Table 6. In addition, the integral estimate can be seen in Fig. 1.

In order to implement the technique, the Fuzzy Logic Toolbox software can be used. Fuzzy Logic Toolbox is a suite of applications included with MatLab. It allows one to create systems of fuzzy inference and fuzzy classification in the framework of the MatLab environment, with the ability to integrate them into Simulink.

Table 6 Summary table aggregation of bankruptcy risk assessments for 5 years

Model	Year 1	Year 2 (%)	Year 3 (%)	Year 4 (%)	Year 5 (%)
Altman-Sabato model [16]	18%	98	98	98	98
Lina-Pesse model [15]	62%	58	59	56	45
JuHa-Tehong model [12]	25%	47	37	47	49
Gruzchinsky model (2003)	0%	1	1	1	1
Zhdanov & Afanasyeva model [9]	X	44	74	76	7
Integral evaluation	31%	54	55	58	48

Source Developed by the authors

4 Discussion

The integrated assessment presented in Table 6 and in Fig. 1 has the characteristics of an "average value" built on the basis of five independent methods of enterprise bankruptcy risk. The list of used techniques can be expanded at the expense of both domestic logit models and foreign analogs. Moreover, the corresponding modification of the model does not require a lot of time. Corresponding adjustments are made automatically by adjusting the weights.

5 Conclusion

A new technique has been developed that allows one to build an integrated assessment of the bankruptcy risk of an enterprise based on existing logit models. The adjustment of the model for industry and time specifics is carried out not by recalculating the coefficients in the original models, but by clarifying the weighting coefficients of the models, based on expert estimates and recommendations. The proposed approach improves the accuracy of assessing the likelihood of bankruptcy, especially in the context of a wide spread of economic values.

References

1. Altman, E.I.: Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. J. Finance **22**, 589–609 (1968)
2. Balcaen, S., Ooghe, H.: 35 years of studies on business failure: an overview of the classic statistical methodologies and their related problems. The British Accounting Review **38**(1), 63–93 (2006)
3. Agarwal, V., Taffler, R.: Comparing the performance of market-based and accounting based bankruptcy prediction models. J. Bank. Finance **32**, 1541–1551 (2008)
4. Tseng, F.M., Lin, L.: A quadratic interval logit model for forecasting bankruptcy. Omega **33**(1), 85–91 (2005)
5. Laitinen, E. K., Laitinen, T.: Bankruptcy prediction: application of the Taylor's expansion in logistic regression. Int. Rev. Fin. Anal. **9**(4), 327–349 (2000)
6. Kuzminov, A.N., Korostieva, N.G., Dzhukha, V.M., Ternovsky, O.A.: Economic Coenosis stability: methodology and findings. Contemp. Issues Bus. Fin. Manag. Eastern Eur. **100**, 61–70 (2018)
7. Zelenkov, Y., Fedorova, E., Chekrizov, D.: Two-step classification method based on genetic algorithm for bankruptcy forecasting. Expert Syst. Appl. **88**. https://doi.org/10.1016/j.eswa.2017.07.025
8. De Andrés, J., Lorca, P.: Bankruptcy forecasting: a hybrid approach using Fuzzy c-means clustering and Multivariate Adaptive Regression Splines (MARS). Expert Syst. Appl. **38**, 1866–1875 (2011)
9. Zhdanov, V.Yu., Afanasyeva, O.A.: A model for diagnosing bankruptcy risk in aviation industry enterprise. Corp. Finance. **4** (20) 77–89 (2011)
10. Ohlson, J.: Financial ratios and the probabilistic prediction of bankruptcy. J. Acc. Res. **19**, 109–131 (1980)

11. Begley, J., Ming, J., Watts, S.: Bankruptcy Classification Errors in the 1980s: An empirical analysis of Altman's and Ohlson's models. Rev. Acc. Stud. **1**, 267–284 (1996)
12. Nam, J.H., Jinn, T.: Bankruptcy prediction: Evidence from Korean listed companies during the IMF crisis. Journal of International Financial Management & Accounting **11**(3), 178–197 (2000)
13. Ginoglou, D., Agorastos, K., Hatzigagios, T.: Predicting corporate failure of problemmatic firms in Greece with LPM logit probit and discriminant analysis models. Journal of Financial Management & Analysis **15**(1), 1 (2002)
14. Gruszczynski, M.: Corporate governance and financial performance of companies in Poland. International Advances in Economic Research **12**(2), 251–259 (2006)
15. Lin, L., Piesse, J.: Identification of corporate distress in UK industrials: a conditional probability analysis approach. Applied Financial Economics **14**(2), 73–82 (2004)
16. Altman, E.I., Sabato, G.: Modelling Credit risk for SMEs: Evidence from the U.S. from the U.S. Market. Abacus **43**(3), 332–357 (2007)
17. Minussi, J., Soopramanien, D.G.R., Worthington, D.J.: Statistical modelling to predict corporate default for Brazilian companies in the context of Basel II using a new set of financial ratios. Lancaster University Management School Working Paper, p. 35 (2007)
18. Muradov, D.A.: Logit-regression models for predicting bankruptcy of enterprises. In: Proceedings of the Russian State University of oil and gas named after I. M. Gubkin, vol. 3, pp. 160–172 (2011)
19. QFinAnalysis.: Retrieved from https://4analytics.ru/programmi-dlya-analiza/finansoviie-analiz-predpriyatiya-za-5-minut-qfinanalysis.html (2019)

Cognitive Approach Imperatives in Modeling and Management

Veronika V. Yankovskaya

Abstract This paper examines the imperatives of the cognitive approach to modeling and management developed in data science. The application of artificial intelligence in making managerial decisions is considered from the perspective of providing an innovative breakthrough in science, technology, and business for accelerated development. Those type of management tasks that require using the cognitive approach are discussed by the author. Some problems and prospects of further development of the cognitive approach and its application for managerial decision making are considered. The author also discusses the concept, essence, and purpose of cognitive technologies, artificial intelligence, and data science, focusing on their role in the decision-making process. The principles of cognitive technology and the procedure for conducting cognitive analysis are discussed in detail, considering various types of analysis relying on artificial intelligence used in practice by business entities. Furthermore, the role of cognitive maps in using cognitive technologies in managerial decision making is considered, along with the problems and prospects for the application of cognitive technologies in practice (foreign experience).

Keywords Cognitive maps and technologies · Artificial intelligence · Psychogeometric testing · Innovative breakthrough

1 Introduction

The twenty first century was marked by the fact that the theory of managerial decision-making, which deals with the tasks of managing systems of various genesis, has become an independent scientific discipline. The methods and approaches used in the theory of managerial decision-making are diverse. Nowadays, in conditions of actively developing informatization of society, a cognitive approach allows us to define a person as a creature that can understand and analyze the amount of information present in the areas in which he lives, works, and makes decisions. At the same

V. V. Yankovskaya (✉)
State University of Management (GUU), Moscow, Russia
e-mail: veronika28-2@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_14

time, a person performs actions, thinks, and feels. If we consider that the thoughts and feelings of each of us are different, then management decisions will be different for each person. Each of us sees and interprets different situations in his own way, subjectively; therefore, our reactions to events will be different. A man reacts and only then subjectively analyzes his behavior (actions), whether it was success or failure; this allows him to adjust his behavior in the future.

2 Materials and Methods

This study used theoretical, empirical, and particular scientific methods. The materials were the work of outstanding scholars in the fields of psychology, management, sociology, and economics; personal observations; and research in the process of preparing methodological material for conducting psychogeometric testing in profilogramming of a decision maker (DM). One of the most prominent psychologists, Ellis, believes that a person's behavior problems are caused, as a rule, by irrational thoughts. Therefore, it is necessary to analyze what happened with the person, taking into account the conclusions drawn. In other words, first, it is necessary to draw up a "cognitive map" of the occurring event.

The primary source of the concept of "cognitive map" is psychology. A cognitive map is a person's process of perceiving the world. In other words, this is the process of obtaining, analyzing, and processing the world around us and its information on physical, spiritual, social, and intellectual levels. The study of cognitive maps made it possible to study the features of cognition for the subject's external and internal environment. The procedure for creating cognitive maps is a complex process of psychological modifications that allow the subject to receive, save, remember, distribute, and perform all kinds of manipulations with information from the environment. Research in psychology is most often aimed at studying these processes since they are an integral part of making managerial decisions. In 1948, E. Tolmen developed a new concept, the "cognitive map".

As a technique, cognitive modeling was developed in sociology and political science, during the post-industrial era from the 1960s to the 1980s, by scientific researcher R. Axelrod. Further development of the indicated aspects was carried out by scholars from Scandinavia and the USA. Devlin [4] and Patrizio [14]. "Cognitive map" is a linguistic and mental representation that allows us to build a model of the process of human thought, determine the policy of further procedures that contribute to the verification of the authenticity of events in the future, and focus on the identified problem. In their studies, Axelrod and his colleagues proved that the subject simplifies the situation extremely if more complex circumstances arise. When developing and making managerial decisions, the interconnection and interdependence of secondary elements and factors, feedback, and possible consequences are not taken into account. Axelrod attributed the models based on cognitive maps to normative maps, believing that the models make it possible to organize a person's cognitive activity in making managerial decisions. Scholars and economists have repeatedly empirically proven that the use of the cognitive approach and cognitive modeling significantly increases the efficiency of managerial decision-making. At the same time, the scholar pointed to a number of drawbacks of existing methods that use reliable data in constructing cognitive maps. C. Iden, an English scholar and economist, proposed a unified approach to building cognitive maps.

In their works, D. Hart and F. Roberts used cognitive modeling in collegial management decision-making. It should be noted that political analysts and sociologists only use cognitive modeling, as well as approaches and methods, to resolve conflict situations that arise due to mutual misunderstanding and the emergence of different opinions about the problem.

3 Results

A cognitive map is an effective tool that allows us to thoroughly analyze a problem characterized by indicators that are difficult to formalize and measure. It helps substantiate and improve the quality of managerial decisions. Cognitive maps also increase the generation of fresh ideas. Today, the cognitive approach and modeling have developed dynamically in foreign and domestic economies [15, 16, 18]. They were developed in response to a search for a mechanism for making managerial decisions using various scientific areas, including cognitive modeling (artificial intelligence), and taking into account data science. In everyday life, we are confronted with various tasks and questions that require our attention and immediate resolution. But how can we keep up with everything and make perfect decisions? This is a topical question not only for people but also for corporations, where one wrong decision can cost a fortune or endanger the life of an economic entity. Scholars and businessmen are close to answering this question. What if we look at our brain and thought processes and break it all apart? What if someone else, not a person, makes decisions? After all, if it is a computer, then it will not know fatigue, rest, or disappointment. Is this not an attractive idea for businesses?

Nowadays, the usual notion of brain processes and the way we make decisions is being replaced by cognitive science and the result of its work—artificial intelligence—a powerful technical and computing machine that can analyze huge amounts of data and produce a ready-made result. In this regard, we can highlight the relevance of the problem—a rather highly unexplored/unstudied process—which is the interconnectedness and interdependence of data science, cognitive technologies, and the influence of artificial intelligence in the process of managerial decision-making in an economic entity. The work of artificial intelligence is implemented wherever there is a need and an opportunity. Ease and reliability, speed of work, and increased accuracy of the analysis attract the attention of specialists, but there are a number of features associated with the work of artificial intelligence.

Firstly, business entities are transformed into mathematical machines. Secondly, the use of cognitive technologies and artificial intelligence in the field of goods and services is wide (for example, Amazon and Google). Leading American companies have long been using developed algorithms to determine purchasing behavior, identify the wishes and needs of the population to improve their work, boost sales of goods, and create an effective advertising campaign. Thirdly, the use of various algorithms that allow one to obtain reliable information leads to a paradigm shift and brings humanity closer to the developed post-industrial world, where the main source of income is information. However,

- spheres that use artificial intelligence require highly qualified specialists (such as programmers, mathematicians, specialists in data science). This leads to a rise in labor costs.
- generated event options, the creation of various types of analysis, and programs and solutions offered by AI all require constant brain flexibility from employees, reducing its performance.
- there is a need for the continuous updating of equipment. High-tech equipment requires huge investments [5].

Despite this, artificial intelligence, whose work is based on cognitive technologies, continues to gain popularity and conquer new areas and industries.

4 Discussion

The study of cognitive maps allowed us to study the features of cognition of the external and internal environment by the subject. Creating cognitive maps is a complex process of psychological modifications that allow the subject to receive, save, remember/not forget, distribute, and perform all kinds of manipulations with information from the environment. In 1948, E. Tolmen developed a new concept, the "cognitive map." Later, as a technique, cognitive modeling developed in sociology and political science. This is the post-industrial era from the 1960s to the 1980s. This happened because of the works of scientific researcher R. Axelrod. In their studies, Axelrod and his colleagues from the United States and Scandinavia proved that, when developing and making managerial decisions, the interconnection and interdependence of secondary elements and factors, feedback and possible consequences are not taken into account.

Scholar-economists have repeatedly empirically proven that the use of the cognitive approach and cognitive modeling significantly increases the efficiency of managerial decision-making. At the same time, it should be noted that these methods have disadvantages. C. Iden, an English scholar and economist, proposed a unified approach to building cognitive maps. In their works, D. Hart and F. Roberts used cognitive modeling in collegial management decision making. A cognitive map is an effective tool that allows us to deeply consider and analyze the problem of difficult-to-formalize indicators, where measurement is not possible. All this helps to improve the quality of managerial decisions and allows them to be substantiated. The generation of fresh ideas increases thanks to cognitive maps.

Today, the cognitive approach and modeling have developed dynamically in both foreign and domestic economies. The main idea of development is the search for a mechanism for making managerial decisions using various scientific areas, including cognitive modeling (artificial intelligence), and taking data science into account. Every movement and every human action, as well as the life process of any organization, is associated with decision-making. Decisions can be strategic, tactical, or operational, depending on the needs and requirements of the organization and the level of decision-making. They can also be taken collectively or individually according to the delegated authority of an employee of an economic entity. Decisions can relate to various fields of activity and life; they are usually divided into social, economic, organizational, or technical [4].

Cognitive technologies are technologies of information content aimed at the formation and comprehensive diversification of the cognitive abilities of an individual. Cognitive technology is instructed to develop the imagination and thinking of the individual [6].

The thinking system and attitude of the environment (the world) are influenced by such factors as ownership, a person's value system, the ability to evaluate oneself and one's actions, the body of knowledge acquired and available for situations requiring opposition, and memory strategies [17].

Based on this, the development of entrepreneurial structures and the effective development of a business in the market depend directly on the quality of management decisions that are assigned to the employees of the organization, that is, ordinary people. The name or level of the position does not play a role here (for example, the manager-analyst). The question or problem of modern business is that the responsibility for making strategically important decisions lies with people who tend to be tired, get sick, go on vacation, burn out, or intentionally harm the company based on their life and goals. Modern business seeks to reduce the percentage of human-factor influence on the process of making managerial decisions, since people tend to make mistakes sometimes, and mistakes can cost companies millions of dollars and lead to bankruptcy or a loss of reputation.

The development of cognitive technologies, that is, a review of the programs and mechanisms of our brain's work, allowed scholars to draw conclusions about the brain's work, how decisions are made, what factors influence a person's decision-making. Accordingly, they laid the foundation for the development of artificial intelligence and the principle of Big Data analysis.

Artificial intelligence (AI)—a science and technology for creating highly developed mechanisms and machines; computer programs. In any case, at the first stage, artificial intelligence is not intended to replace people, but to help solve those tasks that cannot manually be performed by a person due to various circumstances and factors, i.e., it is associated with the initial task of using a computer to facilitate the understanding of human intelligence, while it is not a fact that we will use only biological methods [12].

It is worth noting here that data science is a branch of computer science that studies the problems of analyzing, processing, and displaying data in a digital form [16].

In the process of the organization's life, employees are faced with certain tasks that require immediate decisions. Therefore, how does one make a balanced and optimal decision in conditions of instability and pressure from colleagues or business partners? In this regard, we should note the interest of modern managers in cognitive analysis and, accordingly, the modeling of complex situations, which then facilitates decision-making in the future. The analysis of areas where managerial decision-making is relevant allows us to identify a number of significant features: multidimensionality, interconnectedness, a lack of (most often) sufficient quantitative information, and high dynamics in the variability of processes over time [18].

Everyone knows such social networks as Facebook and Twitter, which have created their own AI startups to study the processes of people communicating in social networks and their behavior in the field of electronic communications.

Apple is also developing 4 of its high-tech endeavors in the field of artificial intelligence. One of the brightest and most visible results was the creation of Face ID, which has conquered the whole world and revolutionized the possibility of protecting gadgets and other mobile devices.

Google and Amazon are using artificial intelligence to develop their platforms and sell various products or services. The process of collecting data, analyzing the behavior of the average user on the data pages of domains, and so on is entrusted to artificial intelligence. Experts take into account the results of the study and make a balanced and rational decision.

Well-known company IBM, a leader in the technology market, is the absolute leader in the use of artificial intelligence. The latest software innovations (like cloud technologies) and the latest software versions are developed on the basis of the analysis of the operation and application of previous products of the company by users [14].

As we can see, the use of cognitive technologies and artificial intelligence has both pros and cons in practice. However, the effect of applying knowledge and capabilities exceeds the expectations of developers and companies, taking them to a new level and making leaders in their fields, which can indicate the effectiveness of this technology.

5 Conclusion

It should be noted that the interest of practitioners in the use of modeling and methods, where the basis is the cognitive approach, in the field of management abroad and in Russia is growing. This, in turn, indicates the need for and feasibility of further research and study of the cognitive approach in management. Within the framework of grant, it is necessary to carry out a number of works to combine artificial intelligence, data science, and a cognitive approach. More attention is paid in this scientific direction to the study of complex, open systems where the main element is the subject, to a greater extent, affecting the effectiveness of managerial decision-making. The field of cognitive technology research and the work of artificial intelligence has not yet reached its peak. Scholars need to conduct more than one study, but the results can already be seen; the eminent psychologist, Ellis, is sure that the person's wrong behavior is provoked by irrational thoughts. Accordingly, the management decision will be more optimal and correct if we analyze what happened, taking into account the conclusions reached by the subject in the course of reflection. For this, a cognitive map of the event is required.

The use of cognitive technologies in practice was due to the creation of artificial intelligence, which greatly facilitated the process of data collection and analysis and, according to the results, brought certain business entities to leading positions. Thus, the capabilities of artificial intelligence lead to an increase in the speed of managerial decision-making. This minimizes the human factor, which negates the occurrence of errors during the implementation of earlier decisions, increases the reliability of the data and analysis, and creates various situations for solving the problem (the "what if" concept), thereby increasing the efficiency of further development in various areas (especially the service sector).

The use of the algorithms created in the likeness of thought processes by artificial intelligence, give amazing results in practice: the reliability of business forecasts increases, the sales sphere becomes more controlled, service development services grow because the organization knows its needs and capabilities, and marketing organizations become balanced [17].

No matter how modern technologies evolve, no matter how science progresses, the last word still remains with man, because it is the unique abilities of the human mind that create what we have now, which means that new achievements and discoveries are waiting to be created by men and women, not artificial intelligence. Although, who knows what else the world of the unidentified and unknown will offer?

Acknowledgements This paper was prepared based on the materials of the project No. 18-07-00275 "Designing convergent technology for the intellectual support of management decisions on an interdisciplinary basis" funded by the RFBR.

References

1. Buchanan, L., O'Connell, A.: A brief history of decision making (2006). Retrieved from https://www.hbr.org/2006/01/a-brief-history-of-decision-making
2. Ceschi, A., Demerouti, E., Sartori, R., Weller, J.: Decision-making processes in the workplace: how exhaustion, lack of resources and job demands impair them and affect performance (2006). Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/28529491
3. De Smet, A., Lackey, G., Leigh M.: Weiss. Untangling your organization's decision making (2018). Retrieved from https://www.mckinsey.com/business-functions/organization/our-insights/untangling-your-organizations-making
4. Devlin, B.: Where is cognitive decision making in BI? TDWI articles (2016). 31.03.2016. Retrieved from https://tdwi.org/articles/2016/03/31/where-is-cognitive-decision-making-3.aspx
5. Dhanrajanii, S.: Reimagining enterprise decision—making with artificial intelligence (2018). Retrieved from https://www.forbes.com/sites/cognitiveworld/2018/10/15/reimagining-enterprise-decision-making-with-artificial-intelligence/

6. Dietrich, C.: Decision making: factors that influences decision making, heuristics used, and decision outcomes (2018). Retrieved from https://www.inquiriesjournal.com/articles/180/decision-making-fac
7. Karam, S., Centobelli, P., D'Addona, D.M., Teti, R.: Online prediction of cutting tool life in turning via cognitive decision making (2016). Retrieved from https://www.sciencedirect.com/science/article/pii/S2212827116000135
8. Kaur, N.: Cognitive decision making in smart industry. Comput. Ind. J. **74**, 151–161 (2015). Retrieved from https://sandeepsood.in/wp-content/uploads/2018/12/Cognitive-decision-making-in-smart-industry.pdf
9. Lebowitz, S.: 20 Cognitive biases that screw up your decisions (2015). Retrieved from https://www.businessinsider.com/cognitive-biases-that-affect-decisions-2015-8
10. Lomazov, V.A., Matorin, S.I., Nekhotina, V.S.: Native model of the decision-making process when choosing methods for evaluating IT projects. Sci. J. "Basic Res." **6**, 490–496 (2015). Retrieved from https://www.fundamental-research.ru/ru/article/view?id=38647
11. Maksimov, V.I., Kornoushenko, S.V.: Cognitive technologies to support managerial decision making. Press, Moscow, Russia (2018)
12. McNamara, G., Bromiley, P.: Decision making in an organizational setting: cognitive and organizational influences on risk assessment in commercial lending. Acad. Manag. J. **40**(5) (2018). Retrieved from https://journals.aom.org/doi/10.5465/256927
13. Nesterova, M.O.: Cognitive technology innovation in the management of socio-economic systems. Scientific notes of the Taurida National University named after V.I. Vernadsky ("Philosophy. Culturology. Political Science"), vol. 27, no. (1–2), pp. 208–216 (2014)
14. Patrizio, A.: Top 25 artificial intelligence companies (2016). Retrieved from https://www.datamation.com/applications/top-25-artificial-intelligence-companies.html
15. Pomerol, J.-C.: Artificial intelligence and human decision making. Eur. J. Oper. Res. (2018). Retrieved from https://www.researchgate.net/publication/222506083_Artificial_intelligence_and_human_decision_making
16. Press, G.: Data scientists: the definition of sexy (2012). Retrieved from https://www.forbes.com/sites/gilpress/2012/09/27/data-scientists-the-definition-of-sexy/#27b92ce5f969
17. Robinson, W.: Moneyball for business: using AI and algorithms in management decision making (2018). Retrieved from https://www.salesforce.com/uk/blog/2018/06/using-ai-and-algorithms-in-management-decision-making
18. Taylor, J.: Cognitive biases are bad for business (2018). Retrieved from https://www.psychologytoday.com/bu/blog/the-power-prime
19. Tremblay, S., Gagnon, J.-F., Lafond, D.: A cognitive prosthesis for complex decision-making. Appl. Ergon. J. **58**, 349–360 (2017). Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/27633232
20. Valiev, S.Z., Fedorova, O.A.: Cognitive technology in managerial decision making. Electron. Sci. J. "Oil Gas Bus." **5**, 687–697 (2015)
21. Zhukova, D.Y., Pogrebnyak, M.I.: HR analytics as a mean of supporting management decision making. Molodoy Uchony **18**(22), 248–250 (2016)

Sustainable Development of Complex Social Systems

Sustainable Green Development of Russia

Aleksandr S. Tulupov, Anatoly F. Mudretsov, and Mikhail G. Prokopiev

Abstract The paper focuses on the issues related to the functioning of the state based on the sustainable development concept. The need for the implementation of this concept is based on the balance of the life of humanity in the environment, economy, and social sphere. The importance of taking into account human potential and the need for the formation and implementation of the concepts of "green economy" and "green growth" are substantiated. The authors formulate the main priorities for the sustainable development of Russia at the present stage and consider a set of tools that contribute to the transition to the path of "green growth."

Keywords Sustainable development · Green economy · Green growth · Human potential · Digital economy

1 Introduction

Almost half a century has passed since the emergence of the concept of sustainable development, and their basic principles must be adhered to by any state. In essence, this concept proceeds from the balance of human life in the environment, economy, and social sphere. The social component implies that humanity acts as the central or main link of the socio-ecological system; that is, a person is a subject of development. This means that a person should participate in processes that form the sphere of his life, contribute to the adoption and implementation of environmentally friendly decisions, and control their implementation. The specifics of sustainable development lies precisely in the prevailing influence of qualitative characteristics and living standards that determine human potential, which is understood as the totality of the physical and spiritual forces of its inhabitants and can be used to achieve individual and social goals. In [7], instrumental goals are identified. They are related to ensuring

A. S. Tulupov (✉) · A. F. Mudretsov · M. G. Prokopiev
Market Economy Institute of RAS, Moscow, Russia
e-mail: tul@bk.ru

A. F. Mudretsov
e-mail: afmudretsov@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_15

the necessary living conditions, including the expansion of the person's potential and the possibilities of their self-realization.

The state's desire for sustainable socio-economic development demonstrated the need to form a type of economy where, in addition to social aspects, the environmental aspects of economic development are taken into account as much as possible. The concept of a "green economy" is based on these principles. This concept in economic science is relatively new since it appeared about 20 years ago [11]. During this period, the "greening" of the economy for post-industrial countries from a desirable but secondary effect has turned into a major development task.

2 Materials and Methods

The notions of "green economy" and "green growth" are increasingly used for denoting the greening process in the world. Since 2009, these terms are increasingly included in the main documents and terminology of international organizations. They are especially comprehensively considered in documents from UN and OECD structures as key terms for the further development of mankind and individual countries (Green Encyclopedia, n.d.). The UNEP experts see the green economy as an economic activity "that enhances human well-being and ensures social justice while significantly reducing environmental risks" (Green Economy: Health, n.d.). This is very similar to the concept of sustainable development, which has a corresponding legal framework status in Russia, but, unfortunately, is not being effectively implemented in economic programs and environmental management practices [13].

The green economy was the impetus for the development of the Green Growth concept, which was first presented in 2005 in Seoul at the 5th Conference of Ministers of Environmental Protection of the Asia–Pacific Region. This concept is the most important tool for ensuring the balance of environmental and economic development. It served as the basis for this study.

3 Results

For Russia's transition to the path of sustainable development, carefully coordinated actions in all areas of the economy, the creation of an organizational and economic mechanism that would ensure the transition to a green economy, and the reorientation of economic, environmental, and social institutions to priority areas are necessary [18]. Currently, there is an urgent need for a transition to an economic model that will increase human well-being while preserving resources and not exposing future generations to significant environmental risks. An important link in the transition to such an economy is the use of the digital economy, which is based directly on computer technology, a global network of economic and social activities, carried out by information and communication technologies such as the Internet, mobile, and sensor networks [2]. The digital economy will ensure the sustainability of the Earth's ecosystem, restore the destroyed areas in this area, in particular by monitoring green "big data," including online screening of a whole range of relevant indicators [12].

Various tools are used to transition to a green economy. At the same time, environmental management and environmental safety problems are interpreted differently in national policies and development strategies of different countries.

In Russia, at the official level, increased attention is paid to environmental and economic issues. Thus, in order to draw attention to problematic issues existing in the environmental sphere, and to improve the state of the country's environmental safety, Russian President V. V. Putin signed a decree [4]. As a result of the Year of Ecology, the understanding of environmental problems' importance and the need to stimulate enterprises' transition to new technologies for reducing the negative impact on the environment has increased.

Thus, it can be noted that the government of the Russian Federation takes a set of appropriate measures to improve the environmental situation. However, the amount of funding for improving environmental quality is not comparable to the scale of the problem, so it's rather difficult to talk about the environmental significance of the measures taken. In our opinion [1, 8, 9, 10], the following relevant directions for the development of the ecological and economic policy of Russia are necessary: firstly, it is necessary to further improve the economic instruments that contribute to the rational use and reproduction of natural resources; secondly, the use of non-traditional ways of financing environmental programs should be expanded; thirdly, which is especially important, it is necessary to consider the issue of ownership of natural resources that have fallen into the "legal trap"—on the one hand, according to the Constitution of the Russian Federation, natural resources are owned by the state, and, on the other hand, they are used inefficiently and, in some cases, natural resources and social wealth are directly squandered.

In our opinion, an effective mechanism for reducing the anthropogenic load is insuring environmental risks [19]. At the same time, both in insurance and in pursuing an environmentally balanced policy, it is necessary to correctly assess the degree of danger of economic entities [13] and losses [20, 21] that are potential or have already been caused as a result of negative impacts on environmental components.

The implementation of the principles of greening and sustainable development in the agro-industrial complex is of the utmost importance, especially for our country.

In order to restore ecological systems, significant financial resources are required, which neither the state nor enterprises have in modern conditions. The emergence of such resources in our country is possible only if you increase your interest in creating a favorable environmental climate, which corresponds to the general ideology of the Russian economic and political reform. However, the reform of environmental and economic systems cannot be based only on the fact that the relationship between economic agents will develop as a form of commodity-money relations.

In order to ensure the financing of the environmental activities of enterprises, it is necessary to create specialized funds for the accumulation of financial resources directed at the protection and reproduction of natural resources. The "green initiatives" developed in recent years can be used for this. They imply drawing attention to specific environmental problems and can be used for sustainable development and assessing the annual costs of financing environmental activities, which will serve to form “green” finance and the implementation of the concept of greening the financial system at the global level. The global banking sector is gaining ground in “green” finance. So, by 2020, the European Bank for Reconstruction and Development has in its portfolio plans to increase the share of green finance to 40%.

The central idea of global cooperation and the unification of financial and “green” issues is to link the procedures for solving global, regional, and national natural-climatic and environmental problems with the tools of modern world financial markets, and to improve global finances and the environment through “greening” the global financial system. Thus, the conditions for harmonious, interdisciplinary synthesis are created. As for Russia, the question of creating a green financial structure is quite relevant. The expert council under the Open Government recommends creating a “green” state bank in Russia with 100% state participation in the bank’s capital. The main goal of such a bank is to finance environmental projects and coordinate work with foreign funds and development institutions, which will level the effect of sanctions.

The best way to attract financing is to issue green bonds that will be acquired by international institutional investors and development institutions and will provide the long money that is especially in demand for green projects.

Green bonds are the most effective mechanism for raising financing for the modernization of equipment and technologies. At the same time, the creation of a specialized bank for green investments is a key element in the concept of Russia’s transition to a green economy. These issues are still under discussion.

4 Conclusion

As our studies have shown, the transition to a green economy requires the implementation of a whole range of interrelated measures aimed at preventing and eliminating internal and external challenges and threats to environmental safety. The proposed measures fully comply with the principles set forth in Government of the Russian Federation [3]. At the same time, it is important that issues of ensuring environmental management and environmental safety within the framework of green growth are supervised in all regions of the country and controlled at the highest level. Nowadays, a whole range of regulatory legal acts has been developed, among which we single out the strategy in Government of the Russian Federation [5] that is the basis for the formation and implementation of a unified state policy for ensuring environmental safety.

In order to implement the main priorities of environmental and economic policy, the implementation of environmentally balanced economic reforms and the creation of an appropriate economic environment at the macroeconomic level are of utmost importance to significantly facilitate Russia’s transition to sustainable development. At the same time, the green economy is an important means of not only greening but also of eradicating poverty and solving a wide range of urgent problems of sustainable development.

Acknowledgements The paper was written as part of the state assignment of the Institute for Market Problems of the Russian Academy of Sciences, the research topic is "Problems of Sustainable Development of Russia: Environmental and Economic Aspect."

References

1. Bezdudnaya, A. G., Ksenofontova, T. Y., Rastova, Y. I., Kraiukhin, G. A., & Tulupov, A.S.: On the Issue of the perspective directions of the science-driven production development in Russia. J. Soc. Sci. Res. **3**, 76–80 (2018). https://doi.org/10.32861/jssr.spi3.76.80
2. Evangelista, R., Guerrieri, P., Meliciani, V.: The economic impact of digital technologies in Europe. Econ. Innov. New Technol. 802–824 (2014)
3. Government of the Russian Federation: Resolution of the Government of the Russian Federation "Environmental Doctrine of the Russian Federation" (August 31, 2002 No. 1225-r). Moscow, Russia. (2002)
4. Government of the Russian Federation: The decree of the President of the Russian Federation "On the Year of Ecology in the Russian Federation" (January 5, 2016 No. 7). Moscow, Russia (2016)
5. Government of the Russian Federation: Decree of the President of the Russian Federation "On the Environmental Security Strategy of the Russian Federation for the period until 2025" (April 19, 2017 No. 176). Moscow, Russia (2017)
6. Green Encyclopedia: Green growth strategy (n.d.). Retrieved from https://greenevolution.ru/enc/wiki/strategiya-zelenogo-rosta.
7. Market Journal: Human potential (2017). Retrieved from https://www.market-journal.com/naporoge/5.html
8. Mudretsov, A.F., Prudnikova, A.A.: The greening of the Russian economy in the context of the formation of market relations. Reg. Probl. Econ. Transform. **3**, 346–353 (2012)
9. Mudretsov, A.F., Tulupov, A.S., Prudnikova, A.A.: Socio-economic development of Russia. Reg. Probl. Econ. Transform. **8**, 4–11 (2017)
10. Mudretsov, A.F., Tulupov, A.S., Prudnikova, A.A.: Features of environmental and economic policy in a market economy. Bull. MIRBIS **4**, 97–102 (2018)
11. Pearce, D., Markandya, A., Barbier, E.: Blueprint for a green economy. Earthscan Publications Ltd., London, UK (1989)
12. Perelet, R.A.: Environmental aspects of the digital economy. World New Econ. **12**(4), 39–45 (2018)
13. Porfiryev, B.N.: The "green" factor of economic growth in the world and in Russia. Problemy Prognozirovaniya **5**(170), 3–12 (2018)
14. Porfiryev, B.N., Tulupov, A.S.: Environmental hazard assessment and forecast of economic damage from industrial accidents. Stud. Russ. Econ. Dev. **6**, 600–607 (2017)
15. Prokopyev, M.: Food consumption and household economies of scale. AIC: Econ. Manag. **2**, 20–31 (2009)
16. Prokopyev, M.: Economic policy in the field of agriculture: methodological approaches. Probl. Theory Pract. Manag. **5**, 20–29 (2012)
17. Prokopyev, M.: The development of measures for adapting the agro-industrial complex of Russia to the WTO conditions: methodological aspects. Probl. Theory Pract. Manag. **6**, 38–44 (2013)
18. Rodionova, I.A., Lipina, S.A.: Green economy in Russia: model and development forecasts. Basic Res. **2**(24), 5462–5466 (2015)

19. Tulupov, A.S.: Environmental insurance. GUU Publishing House, Moscow, Russia (2017a)
20. Tulupov, A.S.: Compensation of environmental damage in the economy of mining. Gornyy Zhurnal **8**, 61–65 (2017b)
21. Tulupov AS, Petrov IV (2018) Fuel and energy complex and methods for assessing the harm from air pollution. In: International Scientific Conference: Knowledge-Based Technologies in Development and Utilization of Mineral Resources. Russia, IOP Conference Series. https://doi.org/10.1088/1755-1315/206/1/012054
22. United Nations: United Nations Environmental Programme: Green Economy (n.d.). Retrieved from https: www.unep.org/greeneconomy/Portals/88/documents/research_products/briefingpapers/Ru_GE_HEALTH.pdf

Modeling the Development of the Economic Security System of Regions as the Basis of Stability

Natalia Glechikova, Vasily Nechaev, and Alexander Seriogin

Abstract The paper focuses on the current state of economic security of the federal districts and regions of the Russian Federation. The authors built a model of an economic security system based on an index assessment. The evaluation criteria show the degree of development of economic security in five options from high to low. The assessment for federal districts and their constituent entities was carried out. The assessment indicators capture the following: population movement, life expectancy of the adult population, population education, labor potential, food security and independence, physical and economic affordability of food for the population, and the generalized level of economic security of the constituent entities of Russia. Each index is characterized by the criteria for assessing the level of economic security of regions and Russia as a whole. The developed model of economic security of the federal districts and their constituent regions includes a system of indicators based on the index approach, from which the overall level of development of the country's economic security is formed. A graphical comparison is made of the dependence of the level of economic security and the coefficient of foreign trade on the subjects of the federation and the federal districts where direct dependence is established. Therefore, stimulating the development of foreign economic activity, both in the region and in the districts, acts as a guarantee of increasing the level of their economic security. It has been established that federal districts and regions with active foreign economic relations have a higher economic potential.

N. Glechikova (✉) · A. Seriogin
Azov-Black Sea Engineering Institute, Branch of Don State Agrarian University, Zernograd, Russia
e-mail: nataliyglechikova@mail.ru

A. Seriogin
e-mail: alexandreseriogin@mail.ru

V. Nechaev
Federal Research Center of Agrarian Economy and Social Development of Rural Areas, All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: vin981@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_16

Keywords Economic security · Regions of Russia · Districts · Model · Security system · Index

1 Introduction

The country's economic interests have always been of particular importance at the international level. The independence of the national economy is the key to the stability and the sustainability of state development. Economic security of both the region and the state as a whole determines the need for evaluation of a system of indicators that meet the quality and duration of a population's life, the development of labor potential and employment, food security and independence, and, of course, indicators of the physical and economic availability of the population.

2 Materials and Methods

Criteria and methods for assessing economic security require an assessment of the system at the international and domestic economic level, as well as at the level of development of federal districts and regions. An assessment at the level of regions and federal districts was made. The indicators used for assessing the development system of the regional economic security are based on smoothing out the differences in the subsystems of natural, economic, social, demographic, and political features of the subject's structure. The modeling of the development of the economic security system is based on the assessment of the target qualitative benchmarks correlating with the initial and forecast situations and their approximation to the target indicators.

3 Results

Economic security includes not only quantitative and qualitative aspects of the regions' state, but also economic, social, and political aspects. These indicators are focused on the development of individual regions, which, together, must ensure real economic growth for the entire system [1–3].

1. The index of population movement (I_{pm}) in the corresponding region is calculated as the arithmetic average of the ratio of the population (Q_{pop}), natural growth (V_{growth}) to the population and the ratio of the sum of the population and migration growth (V_{mig}) to the population. The index value ranges from 0 to 1 or more.

$$I_{pm} = \frac{\frac{Q_{pop}+V_{growth}}{Q_{pop}} + \frac{Q_{pop}+Vmig}{Q_{pop}}}{2}$$

2. The index of life expectancy of an adult population in a region (I_{le}) is defined as the ratio of the difference in life expectancy at birth ($t_{\text{at birth}}$) and minimum life expectancy ($\min_{le}$) to the difference of average maximum life expectancy ($t_{\max le}$) and minimum life expectancy. The index value ranges from 0 to 1.

$$I_{le} = \frac{t_{at\,birth} - \min_{le.}}{\overline{t_{\max_{le}}} - \min_{le}}$$

3. The index of education of the region's population (I_{ed}), is calculated by the well-known method with the adjustments, where, instead of adult literacy, the education coefficient is taken (accounting for higher and secondary education of the adult population). Further, the calculation is the weighted average of the two indices, taking into account the weight factor and the level of education (L_{ed}, weight ratio is 2/3) as well as the proportion of students under the age of 24 ($\propto_{st}^{24}$, weight ratio is 1/3). The value of the indicator ranges from 0 to 1.

$$I_{ed} = \left(\frac{L_{ed}}{100} \times \frac{2}{3}\right) + \left(\frac{\propto_{st}^{24}}{100} \times \frac{1}{3}\right)$$

4. The index of development of labor potential and employment in the region ($I_{l.pot.}$), is calculated as the arithmetic average of the ratio of the number of employed people (Q_{emp}) to the number of able-bodied population (V_{ap}) and the ratio of the number of registered unemployed ($Q_{r.unemp}$) to the total number of unemployed (V_{unemp}). The indicator varies from 0 to 1.

$$I_{l.pot} = \frac{\frac{Q_{emp}}{V_{ap}} + \frac{Q_{r.unemp}}{V_{unemp}}}{2}$$

5. The index of food security and independence of the region ($I_{f.sec}$), is calculated as the ratio of the actual consumption (q) of available food in the region, taking into account the cost of food, (p) to the normative consumption, also taking into account the cost of food. The index varies from 0 to 1 or more.

$$I_{f.sec} = \frac{q_2 \times p}{q_1 \times p}$$

6. The index of physical and economic affordability of food for the population of the analyzed region ($I_{ph.e.aff}$) is defined as the arithmetic average of the ratio of food consumption by national standards (Q_1) to actual consumption (Q_0) and the

ratio of food consumption by the consumption standards to the cost of living. The index varies from 0 to 1 or more.

$$I_{ph.e.aff} = \frac{\frac{Q_1 \times p}{Q_0 \times p} + \frac{q_0 \times p}{q_0^I \times p}}{2}$$

The total index of the development of economic security in Russia (I_{ESrf}) will have the form of the arithmetic average of six indices:

$$I_{ESrf} = \frac{I_{pm} + I_{le} + I_{ed} + I_{l.pot} + I_{f.sec} + I_{ph.e.aff.}}{6}$$

When building a model of economic security (Fig. 1), it is necessary to highlight the stages and specifics of the analyzed entities:

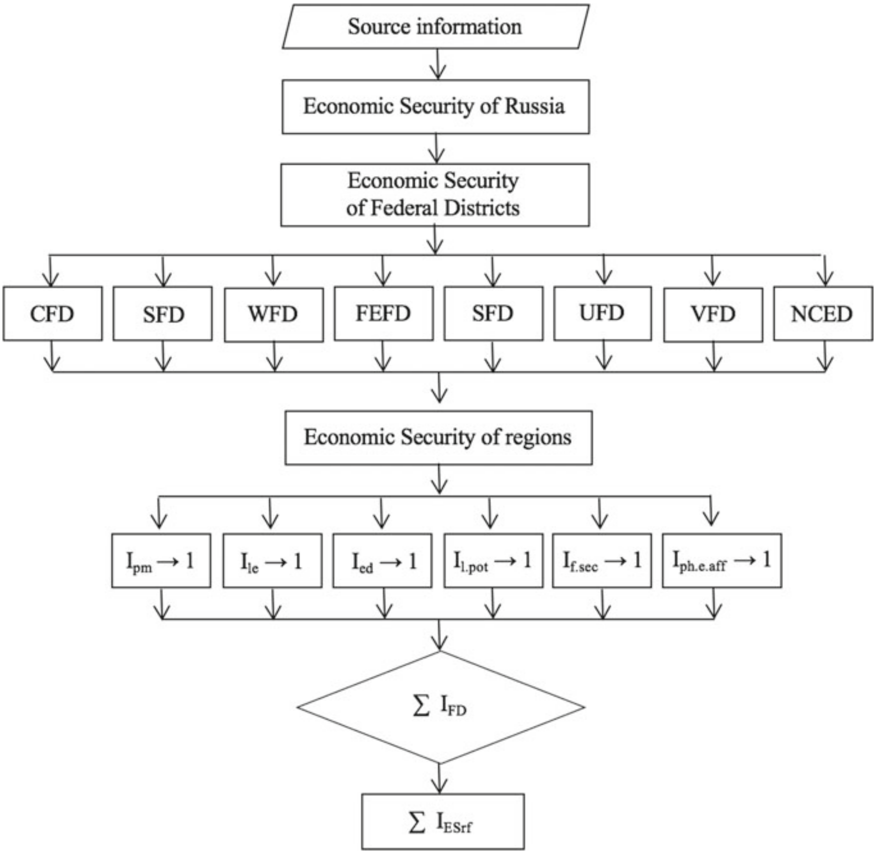

Fig. 1 The model for building economic security of subjects and federal districts

1. to identify the specialization of regions and districts, population movement, level of education, food security, and physical and economic availability;
2. to determine the level of regional economic development by studying the structure and volume of gross regional product and gross domestic product;
3. to calculate the level of economic security of both the subjects and the federal districts;
4. to characterize foreign economic activity through the study of export and import volumes to calculate the coefficient of foreign trade turnover for the constituent entities of Russia and federal districts;
5. to draw the dependence of the level of economic security of regions and federal districts on the development of the foreign economic activity of the region on the basis of calculated data and a graphical construction of dependencies.

At the current level of development of the world economy, where globalization processes play an important role, and international relations are even more closely integrated with economic activity, the expansion of external relations has a significant impact on economic security. The degree of influence has both positive and negative effects. In this, the assessment of economic security indicators is a great methodological task that covers various areas of activity, such as foreign trade relations in the context of exports in the volume of domestic production and the share of imports in domestic consumption. Therefore, the analysis and assessment of the level of the development of economic security should be studied in conjunction with foreign trade.

The level of economic security must be considered in conjunction with factors of internal and external impact on it in order to strengthen the economy of the regions and increase trends in the economic stability of the Russian Federation as a whole. This effect can be traced in the relationship of the level of economic security and the foreign trade turnover coefficient, defined as the ratio of the sum of exports and imports, which in total create foreign trade turnover to the value of GRP or GDP, respectively (Table 1).

The increase in the volume of foreign economic activity and the increase in export-import potential will be a guarantee of increasing the level of economic security of the regions and the country as a whole.

The world rules dictate mandatory participation in world trade as a prospect for economic development. Therefore, weak foreign economic activity can lead to a decrease in the efficiency of economic activity, which is the first step to weakening the level of economic security. The increase in foreign trade, as the integration of the region into the world economy on the basis of the international division of labor, serves as a guarantee of increasing the economic development of the region and its economic security.

The forms of foreign economic activity are foreign trade, cooperation in the field of international exchange of goods, the transition from import of goods to the organization of production through foreign direct investment and other investment activities. The ratio of foreign trade turnover for an example of a specific region is considered

Table 1 Criteria for assessing the degree of development of economic security of regions, federal districts, and the Russian Federation as a whole

The system's economic security	Population movement index	Adult life expectancy index	Population education of index	Labor potential index	Food security and independence index	Index of physical and economic accessibility of food for the population
Increased	1.0	1.0	1.0	1.0	1.0 and more	1.0 and more
Very high	0.8	0.8	0.8	0.8	0.8	1.0
High	0.6	0.6	0.6	0.6	0.6	0.8
Medium	0.4	0.4	0.4	0.4	0.4	0.6
Low	0.2	0.2	0.2	0.2	0.2	0.4

as a set of actions for the exchange of capital, technology, and goods on the foreign market.

The calculation of the economic security of the federal districts and Russia is presented in Table 2.

4 Discussion

Based on the constructed model for the development of the level of economic security and the analysis of the subjects of the Russian Federation and federal districts, we can conclude that foreign trade turnover directly depends on the volume of GRP and GDP. Consequently, the level of economic development affects foreign economic activity in all Russian regions. The exception is two federal districts, the North Caucasus District due to the peculiarities of the economic and geographical situation and the Crimean, due to weak economic development, where the resort area prevails.

5 Conclusion

Summing up, it is important to note that the federal districts engaged in active foreign economic activity and their constituent regions have a higher potential for economic development. In all federal districts, the largest share is exported products. The lower the level of economic security of the region, the weaker is the development of international activity in it and vice versa.

Table 2 The indices of the economic security of the regions of Russia

	The subject of the Russian Federation	Population movement index	Adult life expectancy index	Population education index	Labor potential index	Food security and independence index	The index of physical and economic accessibility of food for the population	The level of economic security of the subject of Russia
1	Central Federal District	0.988	0.724	0.873	0.554	1.074	0.923	0.856
2	Southern Federal District	0.980	0.795	0.853	0.437	1.092	1.025	0.864
3	Northwestern Federal District	1.015	0.721	0.812	0.441	1.00	0.942	0.822
4	Far Eastern Federal District	0.858	0.658	0.718	0.336	0.838	0.803	0.702
5	Siberian Federal District	0.914	0.759	0.797	0.477	1.013	0.923	0.814
6	Ural Federal District	0.973	0.777	0.817	0.478	1.060	1.009	0.852
7	Volga Federal District	0.959	0.749	0.822	0.531	1.043	0.93	0.839
8	North Caucasus Federal District	0.927	0.86	0.757	0.443	0.900	0.848	0.789
9	Crimean Federal District	0.84	0.68	0.82	0.38	0.88	0.79	0.762
	The value of the indicator for the Russian Federation	1.01	0.79	0.89	0.54	1.09	0.976	0.896

Reference

1. Grigoruk, N.E.: Statistics of Foreign Economic Relations and International Trade: A Textbook. MGIMO, Moscow (2014)
2. Laurus, N.S.: Economic security of the regions as the basis of the country's security. Economics and modern management: theory and practice. In: Proceedings from XXII International Scientific and Practical Conference. SibAc, Novosibirsk (2016)
3. Shoev, A.K.: Key indicators of economic security in foreign trade. Molodoy Uchenyy, vol. 7, pp. 71–74. Retrieved from https://moluch.ru/archive/245/56515/ (2019)

The Results of the Phased Survey of Rural People on the Issues of Improving the Environmental Status of Territories

Marina G. Polukhina, Sergey P. Bugaev, and Lyudmila E. Tuchkova

Abstract The study revealed that the vast majority of the rural population consider their place of residence to be environmentally problematic, note the negative impact on their health, the removal and disposal of household waste as the main problem, as well as the elimination of unauthorized landfills. However, rural residents are not ready to actively participate in environmental events and use state resources for these purposes. The importance of socio-economic problems for them prevails over environmental ones. This study directly focuses on the environmental environmental activities and environmental issues. The research object is the environmental situation of five rural municipalities (Mtsensky, Soskovsky, Shablykinsky, Glazunovsky, Bolkhovsky) of the Oryol region, representing all natural and economic zones (Western, Central, and South-Eastern). The research subject is the environmental problems of residents of rural areas that have a direct impact on the development of rural areas in a particular region. In order to determine the ecological situation of the studied territories, possible environmental problems, and the degree of their importance, as well as the environmental behavior of rural residents, respondents were asked to answer a number of environmental issues. Respondents were also asked to answer the question "What measures, in your opinion, need to be taken to improve the ecological condition of rural areas?". In many ways, life in the countryside is inferior to urban. In order to make it more comfortable and favorable, it was important to find out from the villagers what needs to be changed. To this end, respondents were asked to rank social needs by importance. According to the survey, the most important social needs are job security, higher pay checks, and the availability of comfortable housing.

M. G. Polukhina (✉)
Federal Scientific Center of Legumes and Groat Crops, Streletskoye, Russia
e-mail: redhvost@yandex.ru

S. P. Bugaev
Kursk State Agrarian I.I. Ivanov Academy, Kursk, Russia
e-mail: edelveis1997@yandex.ru

L. E. Tuchkova
Orel State University named after I.S. Turgenev, Orel, Russia
e-mail: lutuchka@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_17

Keywords Questioning · Rural areas · Environmental management · Ecological problems · Sustainable development · Grant support

1 Introduction

Sustainable development of rural areas implies a comprehensive, simultaneous development of three main components: social, economic, and environmental. Each of these is inextricably linked with the others. The weak development of one becomes limiting for the others. The intensive development of the economy, as well as the non-rational and extensive use of the environment in recent decades, has led to a sharp increase in the number of environmental problems, which automatically led to problems in the social sphere in the form of a deterioration in the quality of life of the population [9, 10].

This study directly focuses on the environmental component (environmental activities and environmental issues). The object of the study is the environmental situation of rural municipalities.

Environmental activity, being an integral part of sustainable development of rural areas, is aimed at rational nature management, ensuring a high quality of life for people through the creation of a safe, healthy living environment [2].

In addition, it includes the formation of environmental culture among the population, its environmental education, and upbringing.

The guidelines for environmental activities are human needs in creating an environment optimal for modern and future generations [7].

From the standpoint of social ecology, environmental activity is determined by the interaction of three groups of factors: natural, technical, and social [1].

The key factors are social factors that are considered at two levels: macro (environmental policy at the state level) and micro (everyday social interactions among individuals) [6].

Environmental activity is directly related to the application of rational methods of organizing social production in order to reduce the negative impact on the environment and maintain sustainable development [16]. Various types of environmental activities are embodied in the implementation of the environmental policy of the state [17].

In Russia, economic policy is based on a number of fundamental acts of federal significance, such as the "Environmental Doctrine of the Russian Federation" [5], "The Strategy for the Environmental Safety of the Russian Federation until 2025" [12], "Fundamentals of state policy in the field of environmental development of the Russian Federation for the period up to 2030" [11], and the Federal Law "On Environmental Protection" [15]. In order to regulate environmental activities at the level of municipalities, the Federal Law "On General Principles of the Organization of Local Self-Government in the Russian Federation" was approved [15]. In addition, each region has its by-laws, as well as regional and municipal programs related to environmental protection.

More and more authors use the concept of "socio-ecological activity," implying the interaction of individuals with nature based on environmental values and norms. At the same time, the goal of the socio-environmental activity is research, conservation, and renewal of natural resources [14].

According to J. Forrester, the quality of life in modern society directly depends on the level of environmental pollution and a number of other factors. The author of the concept of quality of life believes that a high level of industrial development leads to an increase in population density and environmental pollution, then to an increase in stressful situations and a lower quality of life [3].

2 Materials and Methods

The object of the study was rural residents living in five municipal districts (Mtsensky, Soskovsky, Shablykinsky, Glazunovsky, Bolkhovsky) of the Oryol region, representing all natural and economic zones (Western, Central, and Southeast). The subject of the study was the environmental problems of residents of rural areas that have a direct impact on the development of rural areas in a particular region. The aim of the study was to conduct a survey of rural residents to determine the impact of human activities on the environment, the impact of the environmental situation on the sustainable development of rural areas, the quality of life of villagers, and to identify environmental problems and their solutions, as well as their relevance to rural residents, regarding social and economic problems. A questionnaire was developed to study rural residents' views on the ecological state of the rural territory and areas for further development. Questioning of rural residents was carried out in two stages—in 2013 and 2018—to obtain data in dynamics. The survey involved 636 people (336 people in 2013 and 300 in 2018). After processing the subjective opinions of the respondents, the obtained empirical results were compared to the average indicators for the region and the country as a whole, for which the materials of the Federal State Statistics Service were used.

3 Results

3.1 Ecological Situation of the Surveyed Territories

In order to determine the ecological situation of the studied territories, the possible environmental problems, and the degree of their importance as well as the environmental behavior of rural residents, respondents were asked to answer a number of environmental questions Table 1.

An analysis of the responses shows that only 25.5% of rural residents consider their locality environmentally friendly. Moreover, the number of people who think

Table 1 Distribution of respondents' answers to environmental questions

	Survey 2013		Survey 2018		Total	
	Number of answers	%	Number of answers	%	Number of answers	%
1. Evaluate the environmental status of your locality:						
Environmentally friendly	95	28.3	67	22.3	162	25.5
Environmentally problematic, but the problems are not significant	124	36.9	129	43.0	253	39.8
Environmentally problematic, with significant (acute) problems	117	34.8	104	34.7	221	34.7
2. What are the main environmental problems in your community? (in % of the number who consider their settlement to be problematic; several possible answers are possible)						
Water pollution (rivers, groundwater, etc.)	69	28.6	71	30.5	140	29.5
Soil pollution (agrochemical and industrial pollution)	77	32	68	29.2	145	30.6
Air pollution (gas contamination, industrial emissions)	71	29.5	59	25.3	130	27.4
Unsanitary conditions of the territory (household waste, unauthorized landfills, etc.)	176	73	180	77.3	356	75.1
Increased radiation background	101	41.9	97	41.6	198	41.8
Increased noise	28	11.6	32	13.7	60	12.7

(continued)

Table 1 (continued)

	Survey 2013		Survey 2018		Total	
	Number of answers	%	Number of answers	%	Number of answers	%
Disappearance of animals and plants or a change in their species composition	7	2.9	5	2.1	12	2.5
Distribution: quarantine and dangerous plants, and insects; plant and animal diseases	86	35.7	91	39.1	177	37.3
Relief change (reduction of forest area, shallowing of water bodies, soil erosion, etc.)	15	6.2	18	7.7	33	7
3. The environmental condition of the place of residence negatively affects your health?						
Yes	238	70.8	231	77	469	73.7
No	98	29.2	69	23	167	26.3
4. Which systems and organs of your body have been most negatively affected? (in % of the number of people who believe that the ecological state of the locality has a negative impact on health; there are several possible answers)						
A respiratory system (rhinitis, cough, etc.)	24	10.1	29	12.6	53	11.3
Skin integument (dermatitis, etc.)	32	13.4	41	17.7	73	15.6
Neurology (headaches, sleep disturbances, etc.)	123	51.7	144	62.3	267	56.9
Digestive system	21	8.8	10	4.3	31	6.6
Other	64	26.9	72	31.2	136	29
5. What do you personally do to protect the environment? (several possible answers)						

(continued)

Table 1 (continued)

	Survey 2013		Survey 2018		Total	
	Number of answers	%	Number of answers	%	Number of answers	%
I throw out the garbage only in designated areas	278	82.7	264	88	542	85.2
I collect garbage after trips to the countryside	259	77.1	247	82.3	506	79.6
I participate in neighbourhood clean-ups, cleaning events	176	52.4	198	66	374	58.8
I try not to use plastic bags; I replace them with fabric and reusable plastic bags	98	29.2	120	40	218	34.3
I consume water, gas, electricity, etc. economically	156	46.4	176	58.7	332	52.2
I sort garbage (paper, plastic, food waste, etc.)	23	6.8	17	5.7	40	6.3
None of the above	12	3.6	7	2.3	19	3.0
6. What measures, in your opinion, need to be taken to improve the ecological condition of rural areas? (several possible answers)						
Establish container sites, organize regular garbage collection	177	52.7	201	67	378	59.4
Eliminate unauthorized landfills	198	58.9	212	70.7	410	64.5
Planting green spaces (streets, industrial zones, along roads and highways, etc.)	67	19.9	54	18	121	19

(continued)

Table 1 (continued)

	Survey 2013		Survey 2018		Total	
	Number of answers	%	Number of answers	%	Number of answers	%
Installation of filters for drains, gas traps, technical modernization of production by industrial enterprises	98	29.2	81	27	179	28.1
Strengthening the state control over compliance with environmental legislation by enterprises	85	25.3	104	34.7	189	29.7
Recycling garbage, not storing it at the landfill	120	35.7	111	37	231	36.3
Fighting against cow-parsnip	69	20.5	65	21.7	134	21.1
Developing the rural engineering infrastructure	115	34.2	124	41.3	239	37.6
Catching stray animals	64	19.0	58	19.3	122	19.2

Source Compiled by the author

so has decreased by 6% between 2018 and 2013. More and more respondents note minor environmental problems (43% of the respondents in 2018 compared to 36.9% in 2013).

The number of respondents who believe that environmental problems are significant and even acute is stable at 34.7% and has not changed over the years.

These mostly include rural residents living near large enterprises, unauthorized landfills, and others of the like. Among the existing objects located on the surveyed territory, the most aggressive activities can be identified JSC "Sugar Plant 'Otradinsky'" (Mtsensk District), LLC "Mtsensk distillery 'Orlovskaya Fortress'" (Mtsensk District). The above-mentioned objects of the processing industry are characterized by such waste as defecation mud, bard, beet pulp, and molasses. Their uncontrolled removal of agricultural land and discharge into rivers leads to biological pollution. In addition, wastewater from production, pesticides, and other sources gets into the soil and water bodies, as well as lubricants; air pollution occurs with fumes of biological waste, as well as $CaCO_3$ dust from drying of defecation mud, and so forth [9, 10]. Also, in the Mtsensk district and near the city of Mtsensk, there is a landfill for municipal construction waste in a quarry on agricultural lands and a large landfill. Moreover, there are spontaneous dumps everywhere.

Further, the question, "indicate the main environmental problems of your locality" was answered by 74.5% of respondents who believe that their locality is environmentally problematic.

Thus, it turned out that the most noteworthy environmental problem for the population was the unsanitary state of the territory, which accounts for 75.1% of the respondents' answers. Comparing the results of 2013 and 2018, we can see that in 2018 this answer was chosen more often by 5.3 percentage points. Natural dumps occur everywhere because of the absence of container sites in the village, their insufficient number, and irregular garbage collection. The presence of container sites, unfortunately, is not a guarantee of cleanliness. Often, garbage removal is carried out only from containers. Rural residents complain that garbage that does not fit in the container is not taken out, i.e., the container site is turning into a landfill. There is an accumulation of methane, hydrogen sulfide, ammonia, carbon monoxide, and benzene in the air, and an accumulation in the soil and penetration into the groundwater of heavy metals, petroleum products, nitrates, hydrocarbonates, etc.

An increased radiation background worries 41.8% of respondents; their percentage is stable and does not change over the years. This concern is easily explained. Settlements in three of the five surveyed areas (Bolkhovsky, Soskovsky, and Shablykinsky) are located within the boundaries of the radioactive contamination zone that was created due to the Chernobyl disaster.

The distribution of quarantine and dangerous plants, plant, and animal diseases was chosen by 37.3% of the respondents. The percentage of respondents who chose this answer grew in 2018 by 3.4 percentage points compared to 2013. Most often, respondents expressed concern about the increase in the number of those infected with Borschevik and the frequent outbreaks of swine fever in Sosnovsky. [[[AUTHOR: Please verify the edits in the previous sentence. Thank you.]]].

Pollution of water, soil, and air worries 27.4–30.6% of the respondents. Agricultural, processing, and transport industries and underdeveloped engineering infrastructure are the sources of pollution. Of the surveyed 636 people, 39% live in a separate apartment or in a private house with partial amenities, while 2.3% live in a private house without amenities. The rural housing stock is significantly inferior to the urban housing stock in terms of improvement and comfort. In 2015, 57% of rural settlements had the central sewerage system; in the Oryol region, this figure was 50.3%. Also, rural sewer networks are largely worn out and need to be replaced (33%); as a rule, they do not cover the entire settlement [9,10].

To the question "Does the ecological condition of the place of residence negatively affect your health?" 73.7% of the respondents answered positively. These respondents were further asked to indicate which systems and organs of their body were most affected. The respondents indicated neurological disorders (frequent headaches) (56.9%) and skin diseases (dermatitis of various etiologies) (15.6%). The answer "other" was chosen by 29% of respondents. By "other," respondents most often had in mind oncological diseases, general malaise, lack of energy, low immunity, frequent incidence of acute respiratory infections, and ARVI. In estimating the total incidence of the urban population in the country, its decrease by 7.5% between 2013 and 2015 can be noted. At the same time that the incidence of the rural population increased by 1.8% over the same period and amounted to 12,317.5 cases per 10,000 people in 2015, the incidence of the urban population was 3703.2 cases per 10,000 people.

In order to clarify the environmental activity of the rural population, the respondents were asked, "What do you personally do to protect the environment?" along with several answers from which to choose.

Analyzing the answers, it can be concluded that the environmental activity of the villagers is limited to the emission of garbage in specially designated areas (85.2%), collecting garbage after trips to nature (79.6%), and participation in cleanups (58.8%). Respondents who economically consume water, gas, and electricity were at 52.2%. However, they do not do it for environmental reasons, but, according to many respondents, because of their high communal cost.

Virtually none of the surveyed villagers sorted the garbage (only 6.3%). We point out that this event for the Oryol region, unfortunately, is not relevant, because of the centralized garbage collection without separation.

4 Discussion

Respondents were asked to answer the question: "What measures, in your opinion, should be taken to improve the ecological condition of rural territories?" (several possible answers are possible). The distribution of answers is presented in Table 1.

Most of the respondents considered the following primary measures to improve the ecological condition of rural areas: eliminate unauthorized landfills (64.5%) and establish container sites, as well as organize regular garbage collection (59.4%). Slightly more than a third of respondents believe that it is necessary to develop the engineering infrastructure of the village, that is, eliminate cesspools, conduct central sewage (37.6%), and recycle waste rather than store it at landfills (36.3%).

It is worth mentioning that the state, for its part, in the framework of the implementation of the federal target program "Sustainable development of rural territories for 2014–2017 and for the period until 2020" and the state program "Sustainable development of rural territories in Oryol region for 2014–2017 and for the period until 2020" [4] provide grant support to local initiatives by providing grants in the amount of up to 60% of the total project cost, or ₽ 2 million, on an irrevocable basis to the local government or territorial public self-government of the rural settlement for the implementation of socially significant non-profit projects with the participation of citizens living in rural areas in three priority areas of support: the creation and arrangement of recreation areas, sports, and children's playgrounds, conservation and restoration of natural landscapes (cleaning of reservoirs, coastal zones, forest stands, and historical and cultural monuments); and support of national cultural traditions, folk crafts, and crafts [13]. Over the five years (2014–2018) of the implementation of grant support to local initiatives of rural citizens living in the rural areas of the Oryol region, 12 projects were implemented. Only one of them was related to improving the environmental situation (cleaning water bodies in the village of Ostrov in the Livensky district).

To the question "What, in your opinion, first of all needs to be built or improved in your locality?", only 5.9% of respondents spoke in favor of solving the problem of garbage removal.

In many ways, life in the countryside is inferior to the urban lifestyle. In order to make it more comfortable and favorable, it was important to find out what needs to be changed from the locals. To this end, respondents were asked to rank social needs by importance. According to respondents, the most important social needs are job security, higher pay, and the availability of comfortable housing. Less important needs were the development of social infrastructure, comfortable living conditions, etc.; environmental protection was in tenth place out of twelve possible.

5 Conclusion

Summing up, we can say that: environmental issues of rural areas concern their residents. However, solving environmental problems is second in importance in comparison with the accumulated socio-economic problems of rural areas. In other words, environmental projects do not have relevance for rural residents until their primary needs are realized. Thus, according to Maslow's pyramid of needs [8], unresolved generational issues of family income are more relevant to environmental safety aspects. However, not solving environmental problems can lead to more serious problems related to health and demographics.

References

1. Babkin, V.O.: Social ecology as a new developing discipline and its relationship with human ecology. News Orenburg State Agrarian Univ. **3**, 183–186 (2014)
2. Busygin, A.G., Makeeva, E.D., Pavlovsky, V.A.: The role of the discipline "environmental organizations and movements" in the formation of general cultural professional competencies of environmental students of the second level of training (masters). Baltic Humanitarian Mag. **5**(3), 99–101 (2016)
3. Forrester, J.: World dynamics. Nauka, Moscow, Russia (1978)
4. Government of the Oryol region: Resolution "On approval of the state program of the Oryol region, Sustainable development of rural territories of the Oryol region for 2014–2017 and for the period until 2020", 4 Dec 2013, No. 411, Orel, Russia (2013)
5. Government of the Russian Federation: Resolution "Environmental Doctrine of the Russian Federation", 31 Aug 2002, № 1225-r, Moscow, Russia (2002)

6. Kipriyanova, M.A.: On the place of social ecology in sociology. Hist. Socio-Educ. Thought **2**, 152–157 (2013)
7. Krasnobaev, Yu.P.: Modern approaches to the conservation of biological diversity within the boundaries of one of the largest agglomerations of Russia-Samara-Togliatti (on the example of the Zhigulevsky Reserve). Karelian Sci. J. **3**(16), 56–58 (2016)
8. Maslow, A.H.: Motivation and personality. Harpaer & Row, New York (1954)
9. Polukhina, M.G.: Engineering infrastructure as an element of rural development. Bull. Moscow Pedagogical Univ. **1**(15), 33–47 (2018)
10. Polukhina, M. G.: Environmental management is the main factor in the socio-economic development of rural areas. Sci. J. Natl. Res. Univ. Inf. Technol. Mech. Optics. Ser.: Econ. Environ. Manage. **2**, 91–102 (2018)
11. President of the Russian Federation: Decree "Fundamentals of state policy in the field of environmental development of the Russian Federation for the period until 2030", 30 Apr 2012, no. 2423-r, Moscow, Russia (2012)
12. President of the Russian Federation: Decree "On the Environmental Security Strategy of the Russian Federation for the period until 2025", 19 Apr 2017, No. 176, Moscow, Russia (2017)
13. Rosinformagroteh: Recommendations on the application of the grant support mechanism for local initiatives of citizens living in rural areas. Rosinformagroteh, Moscow, Russia (2016)
14. Shilova, V. S.: Socio-ecological activity: theoretical background of the study. Sci. Result Ser.: Pedagogy Psychol. Educ. **1**, 101–106 (2014)
15. State Duma of the Russian Federation: Federal Law "On Environmental Protection", 1 Oct 2002, No. 7-FZ, Moscow, Russia (2002)
16. State Duma of the Russian Federation: Federal Law "On General Principles of the Organization of Local Self-Government in the Russian Federation", 6 Oct 2003, No. 131-FZ, Moscow, Russia (2003)
17. Zaznobina, N. I., Molkova, E. D., Gelashvili, D. B.: Comparative dynamics of socio-ecological-economic systems of Russia and some countries of the Big Twenty (G20) based on the generalized desirability function. Karelian Sci. J. **3**(16), 45–48 (2016)

The Estimation of Factor Activity of the Productive Forces of the Region

Yuri T. Farinyuk, Anna G. Glebova, and Konstantin A. Kotelnikov

Abstract Nowadays, the scientific community focuses on the search for root causes, conditions, and factors for the development of the territory; research and construction of feedbacks; disclosure of the features and particular aspects of economic activity in a system of any level, as well as their reasonable and conscious regulation in the production process, which is not feasible without activating the entire complex of productive forces in the region. The object of the study is the productive forces of the region. The purpose of the study is to show the relationship between the integral indicator of the activity of productive forces and gross regional product (GRP). The paper proposes a system of indicators of the territorial development of productive forces, which are compared through correlation analysis with basic indicators of socio-economic development. Further, the reaction of the socio-economic system of the territory to a change in economic parameters and institutional conditions for the functioning of productive forces in the region's space is revealed. A stable direct relationship between the integral indicator of the activity of productive forces and the gross regional product is proved. The use of the algorithm proposed in the paper will highlight the productive forces of the region and conduct a comprehensive analysis of their condition, which, together with a subsequent assessment of the degree of mutual influence of the production and socio-economic sphere of the region, will help to solve a number of practical issues of the region.

Keywords Productive forces of the region · Gross regional product · Region activity

Y. T. Farinyuk
Tver State Agricultural Academy, Tver, Russia
e-mail: ikc_tver@mail.ru

A. G. Glebova
Financial University Under the Government of the Russian Federation, Moscow, Russia
e-mail: nauka_rf@mail.ru

K. A. Kotelnikov (✉)
Tver State Technical University, Tver, Russia
e-mail: ikostey@live.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_18

1 Introduction

Nowadays, in the theory and practice of the regional economy, insufficient attention is paid to the development and distribution of productive forces. At the modern historic stage, the new geopolitical conditions for the existence of our country has put forward the tasks that are directly related to ensuring a rational process of using the productive forces of the territory [1, 3, 5, 11].

Nowadays, the urgent tasks are the formation of a system of optimal economic relations; quality assurance of the regime of effective environmental management with an emphasis on maintaining ecological balance; the comprehensive disclosure of the production, investment, and human potential of the region; the task of the support of innovative business [4, 12]. Despite the growing interest in the problems of the development of productive forces, nowadays, neither a domestic nor foreign literature has developed a common, unified approach to the logic of the development of productive forces in the context of the regional economy.

Today, despite the conceptual aspects, the scientific approach of different years is dominated by the general approach to the nature and structure of the productive forces of the territory, which suggests understanding the complex of productive forces as the totality of the elements that somehow take part in the creation and distribution of public goods. In this approach, the tendency towards the expansion of the elements of the platform of productive forces is clearly traced, and all interpretations, with a certain degree of reduction, are reduced to the sum of the elements without explaining the process of their interaction or course of development [2, 6, 8, 10]. At the same time, it is clear that they are inadequate to depict the sum of the elements organized on the principle of mechanical connection. In the process of their interaction, they form a complex system, and each integral and indivisible system is qualitatively different from the sum of its components.

2 Materials and Methods

In order to monitor activity, evaluate the vector and measures of managerial impact on the structure of the productive forces of the region, and identify and study the dependence in the development of the economy on productive forces, we systematized a set of indicators and developed an "algorithm for evaluating factor activity of productive forces." The main component in this indicator is "the index of factor activity of the productive forces of the region," also introduced and tested by the authors during the study [7]. This circumstance allowed us (guided not only by contemplative and creative thinking, but also by the result of empirical research) to prove that transformations in the spatial aspect, and ultimately the degree of socio-economic development of the territory, are mainly dependent on the level of formation and development of productive forces, as well as on the effectiveness of their economic use.

Any particular study deals with sample data from some general totality. The developed algorithm is based on the principle of the elimination of absolute data with subsequent aggregation and weighting of activity indicators of the territory's productive forces. As a result, the system of indicators obtained in this way and the distinguished analytical index (being a form of the average index of the individual ones, where each takes its own constant, definite relationship to the structure of productive forces) allows us to combine and identify patterns of the development and mutual influence of factor elements of productive forces, both on each other and the resulting indicator of economic development of the region (GRP). The correlation relation was chosen as the relevance condition.

Given the format of the work, the authors consider it necessary to provide an extremely concise algorithm for assessing the factor activity of the territory's productive forces while explaining the key features of its use in the main stages.

Stage 1. An array of data based on the entire set of elements of productive forces in absolute terms, where the factors: a—the number of people employed in the region's economy from the total able-bodied population, thousand people; b—the output material flow by integrated types of logistics activity in the region, thousand tons; c—complex natural resources (land, mineral, biological, energy, etc.) located in the region, thousand hectares; d—the debts of regional organizations on loans and borrowings, ₽ million; e—the number of patents for utility models, advanced manufacturing technologies and inventions, units; A—complex performance indicator (the activity of power forces): $A = a \times b \times c \times d \times e$.

I^j_A—is an individual index of factor activity of the *j*-th element of power forces (a, b, c, d, e) in % during the reporting period t_1 to the base period t_0 –: $I_A{}^j = Q_{t_1}{}^j$ВБД$Q_{t_0}{}^j$√Ч100; where Q^j—in fact, the value of the *j*-th element of productive forces in absolute values for the reporting and base period, respectively.

The index of factor activity of power forces in the region is proposed to be calculated as $I_A = i_{t_1}{}^n / i_{t_0}{}^n$ √Ч100; where I_A—the index of factor activity of the productive forces of the region for the reporting period t_1, in %; wherein i^n_t—the multiplicative indicator of the activity of productive forces by the number of indexed factor units for the reporting period t_1 and base period t_0, besides $i_t{}^n = i_A{}^j$√ЧВА¶n; where n is the number of indexed factor units of productive forces.

Stage 2. Factor analysis is based on the principles of a representative sample of the average value of the indexed value in the dynamics of a number of years of research and its subsequent decomposition into the constituent elements of the power forces (a sequential-chain method of factor analysis of the desired value was used), for highlighting the influence of each of the previously identified factors of the region's productive forces on the resulting indicator, which, in the study, is the volume of GRP.

Based on this statement, the following equality can be used: $I_A = I_A{}^a$√Ч$I_A{}^b$√Ч$I_A{}^c$√Ч$I_A{}^d$√Ч$I_A{}^e$, where I^a_A, I^b_A, I^c_A, I^d_A, and I^e_A are the selected elements of power forces. The total change in the activity of power forces can be found as the sum of the absolute changes due to each of the factors:

$\text{вЦ} \geq_A = A_1 - A_0 = \text{вЦ} \geq_A{}^a + \text{вЦ} \geq_A{}^b + \text{вЦ} \geq_A{}^c + \text{вЦ} \geq_A{}^d + \text{вЦ} \geq_A{}^e = a_1b_1c_1d_1e_1 - a_0b_0c_0d_0e_0;$
due to factor the "a": $\text{вЦ} \geq_A{}^a = (a_1 - a_0)b_1c_1d_1e_1;$ due to factor "b": $\text{вЦ} \geq_A{}^b = a_0(b_1 - b_0)c_1d_1e_1;$ due to factor "c": $\text{вЦ} \geq_A{}^c = a_0b_0(c_1 - c_0)d_1e_1;$ due to factor "d": $\text{вЦ} \geq_A{}^d = a_0b_0c_0(d_1 - d_0)e_1;$ due to factor "e": $\text{вЦ} \geq_A{}^e = a_0b_0c_0d_0(e_1 - e_0).$

Thus, the factor indices (adjusted for factor) are based on the following calculation sequences: $I_A^a = (a_1b_1c_1d_1e_1)/(a_0b_1c_1d_1e_1)$; $I_A^b = (a_0b_1c_1d_1e_1)/(a_0b_0c_1d_1e_1)$; $I_A^c = a_0b_0c_1d_1e_1/a_0b_0c_0d_1e_1$. In turn, $I_A^d = (a_0b_0c_0d_1e_1)/(a_0b_0c_0d_0e_1)$; $I_A^e = (a_0b_0c_0d_0e_1)/(a_0b_0c_0d_0e_0)$. However, clearly $I_A = A_1\text{вБДА}_o = (a_1b_1c_1d_1e_1)/(a_0b_0c_0d_0e_0) = I_A{}^a\sqrt{}\text{ЧI}_A{}^b\sqrt{}\text{ЧI}_A{}^c\sqrt{}\text{ЧI}_A{}^d\sqrt{}\text{ЧI}_A{}^e.$ The measure of the participation of each selected factor item of power forces in the magnitude of the result is the change in the index factor activity of power forces in the region as private figures and, in general, for a selected period of observation: $I_A = I_A{}^a\sqrt{}\text{ЧI}_A{}^b\sqrt{}\text{ЧI}_A{}^c\sqrt{}\text{ЧI}_A{}^d\sqrt{}\text{ЧI}_A{}^e$, where $I_A{}^j = \text{ɨ}_A{}^j / t$.

Stage 3. The impact of the activity of the productive forces of the region is assessed by correlating the index obtained with the final result by determining the correlation coefficient of Fechner signs K_f: $K_f = (\text{вИСn}_a - \text{вИСn}_b)/(\text{вИСn}_a + \text{вИСn}_b)$ in the form of a previously indexed GRP value in which the correlation relation is used: $y = f(x_1, x_2, x_n)$ where y—the effective sign (GRP); x—the factor signs of the elements of power forces: a, b, c, d, e; f—the function determining the relationship of the analyzed phenomena, factor signs.

3 Discussion

The aggregation of the data array and its subsequent analysis in the first two stages are used to trace the activity of powerful forces in the dynamics over several years. Mostly, the last 3rd stage of the study was introduced by the authors in the proposed algorithm to correlate the result obtained earlier with a real economic indicator (GRP) not intuitively (based only on the essence of the posed question) but based on existing relations between the effective and the determinant indicators.

Following the study's internal logic, if the causal relationship between the analyzed characteristics are emphasized, as well as maximum abstraction from other (latent) factor elements of productive forces that we have not yet introduced into this theoretical model, establish a close correlation between the indicative level of activity productive forces—a comparable GRP value—it is possible to objectively (with a high degree of probability) prove the assumption that there is GRP, which is nothing but a reflection of the activity of the productive forces in absolute terms.

Covering the whole range of application possibilities, this algorithm allows us to track the dynamics and identify both bottlenecks and territorial development guidelines, which will allow us to normalize the measure of managerial impact on each element of the region's productive forces, thereby increasing GRP. Following the study's internal logic, it is necessary to note the causal relationship between the analyzed characteristics. Also, the maximum abstraction from other (latent) factor elements of productive forces that we have not yet introduced into this theoretical model, establish a close correlation between the indicative level of activity productive forces (a comparable GRP value).

Consequently, it is possible to objectively (with a high degree of probability) prove the assumption that there is GRP, which is nothing but a reflection of the activity of the productive forces in absolute terms. It allows the Government of Russia to perform control functions, pursue a sound and balanced policy, and implement considerations of national and regional interest to solve the important tasks of sustainable socio-economic development.

4 Conclusion

The authors tested the topic algorithm on the materials of the Tver region and calculated the dynamics of activity indicators for each factor of the region's productive forces; results are reflected in the Table 1.

In the dynamics of the indicators under consideration, there is a clear non-uniformity of value visible in the following diagram (Fig. 1).

Table 1 The dynamics of the activity indicators of power forces

Period (year)	Data in initial values for a number of factor elements of power forces of the region				
	a	b	c	d	e
2012	580.9	30.0	7875.7	74,413	183
2013	578.2	28.2	7875.6	67,188	180
2014	575.5	28.9	7875.5	69,704	182
2015	630.1	26.6	7874.3	78,935	175
2016	608.5	30.8	7874.1	73,824	169
2017	610.0	27.2	7874.0	68,465	205
Period (year)	The index of factor activity of power forces of the region				
	a	b	c	d	e
2012	1	1	1	1	1
2013	0.994	1.025	1.048	0.901	0.983
2014	0.989	0.963	0.864	0.936	0.994
2015	1.084	0.885	0.923	1.059	0.956
2016	1.046	1.126	0.998	0.991	0.924
2017	1.049	0.905	0.926	0.919	1.121
Average	1.027	0.984	0.959	0.967	0.996

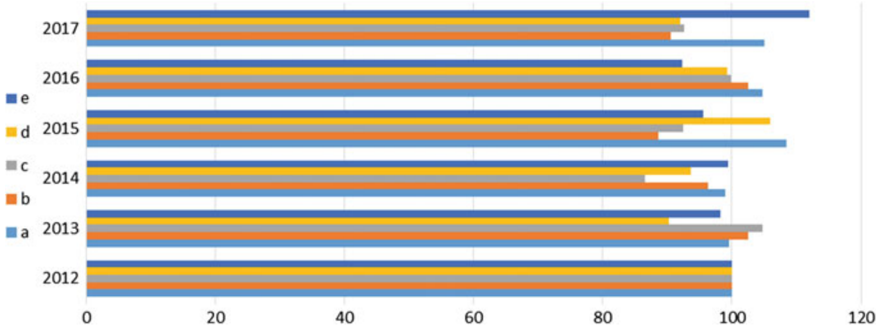

Fig. 1 The dynamics of the activity indicators of power forces

Table 2 The influence of factors of productive forces on GRP in absolute (constant) values

GRP for the base period (₽ million)	GRP while maintaining the dynamics (₽ million)	$I_{\bar{A}}$, in %	The predicted influence of individual factor elements of the productive forces of the territory on the regional GRP (₽ million)				
			a	b	c	d	e
268,063.9	250,103.6	93.3	25,198.0	−4289.1	−10,990.7	−8846.2	−1072.3

Therefore, we can conclude that in the period from 2012 to 2017, the maximum (negative and positive) value in the structure of the activity index of the power forces of the region have factors "a" (the number of people employed in the region's economy out of the total number of able-bodied people, thousand people) and "c" (complex natural resources (land, mineral, biological, energy, etc.) located in the region's space thousand hectares. The latest period was not analyzed due to the lack of calculation of official data for the territorial body in the Tver region [9]).

An approximation of the share of each element in the composition of the index of factor activity of power forces by a normalizing value is presented below (Table 2).

At an average level of activity of the region's productive forces by the factor "a" the positive dynamics is observed, mainly due to an increase in the load on labor resources while reducing their potential to 741.1 thousand people. At the same time, this value is leveled out by the "drawdown" for the other factor elements of the power forces "b," "c," "d," and "e" where, showing negative dynamics of the indicators throughout almost the entire analyzed period, they act as the "bottleneck" of the whole system.

It is possible to say with a certain degree of confidence, that the indicators of the activity of power forces by factors "c" (integrated natural resources) and "d" (financial and credit system of the region) are expressed by a slightly noticeable decrease in GRP by 4 and 3%, respectively. And if, as we believe, the consequences of the sanctions policy of Western partners are reflected in the financial and credit system of the region, a decrease in its activity is entirely expected and predictable under the current situation in the political arena, which has grown into a macroeconomic plane, then the natural resources of the territory are simply not used, or operated inappropriately. The activity indicators of the logistics system "b" are also characterized by fluctuations, partly due to the same reasons, the search for key partners, and the construction of new economic ties; this process is most noticeable in terms of cargo turnover. At the same time, despite often negative dynamics indicators, an increase in activity by the "e" factor (science as an element of the productive forces) in terms of the research, development, and implementation of advanced production technologies (this is clearly visible in the diagram) is a significant reserve for increasing GRP.

Thus, using the proposed methodology (if necessary attention is paid to each factor element of the productive forces individually and to the power forces as a system complex of inextricably linked elements as a whole and their corresponding adjustment), the authorities of the constituent entities of Russia are able to control the dynamics of GRP, reducing the impact of the negative affecting power forces and enhancing the impact of positive influencing factors.

References

1. Block, F., Hirschhorn, L.: New productive forces and the contradictions of contemporary capitalism: a post-industrial perspective. Theor. Soc. **7**(3), 363–395 (1979)
2. Chub, A.A.: Russian regions: sustainability factors and institutional preconditions for development in the context of globalization. Rior. Infra-M, Moscow (2017)
3. Cuadrado-Roura, J. R., Maroto-Sánchez, A.: Regional productivity convergence and changes in the productive structure. In: Cuadrado-Roura, J. (ed.) Regional policy, economic growth and convergence. Springer, Berlin (2009)
4. Glebova, A.G., Malysheva, N.V.: The formation of a system of methods for distributing state support in the region. Agric. Land Law **6**(126), 38–43 (2015)
5. Granberg, A.: Regional science and new regional policy in Russia. In: Chatterji, M. (ed.) Regional science: perspectives for the future. Palgrave Macmillan, London (1997)
6. Grinin, L.E.: Productive forces and the historical process. ComBook, Moscow (2006)
7. Kotelnikov, K. A.: A comprehensive indicative assessment of the socio-economic development of the region (based on the materials of the Tver region). In: Evstifeeva, E. A., Rassadin, S. V. (eds.) Self-developing environment of a Technical University. Moscow (2017)
8. Kotlyakov, V.M. (ed.): Fundamental problems of the spatial development of the Russian Federation: an interdisciplinary synthesis. Media-Press, Moscow (2013)
9. Kulakov, V. G., Egorova, N. T. (eds.): The gross regional product of the Tver region in 2000–2016 is a contribution to the Russian economy. Territorial authority of the Federal State Statistics Service of the Tver Region, Tver, Russia (2018)
10. Lesh, A.: Spatial organization of the economy. Nauka, Moscow (2007)
11. Vence-Deza, X.: Innovation, regional development, and technology policy: new spatial trends in industrialization and the emergence of regionalization of technology policy. In: Vence-Deza, X., Metcalfe, J. S. (eds.) Wealth from diversity. Economics of science, technology and innovation, vol 9. Springer, Boston, MA (1996)
12. Veselovsky, M.Y., Gnezdova, J.V., Glebova, A.G., Nikolskaya, V.A., Lebedev, A.Y.: Innovative transformation of the Russian industry in the framework of digital technologies. Espacios **39**(41), 35 (2018)

A Comparative Analysis of Tax Systems in Russia and Germany

Konstantin Y. Reshetov, Viktor I. Mysachenko, and Anna S. Mikhailova

Abstract Effective construction of the tax system, which policy is a powerful tool for managing the economy, is of particular importance in the contemporary market conditions. The paper focuses on the analysis of the tax systems of Russia and Germany, their principles of formation, and structure of construction in general, discusses ways of improving and prospects for the development of the Russian tax system with the use of foreign experience. The purpose of this paper is to study the structure and principles of the formation of the tax system in Germany and Russia, as well as assess their functioning. Statistical information of financial authorities for 2016–2018, electronic resources of tax authorities, and information and legal portals were used for the analysis. The work applied the methods of a systematic approach, economic, and statistical analysis. The principles of building tax systems, basic tax rates, procedures for calculating individual taxes, the procedure for calculating tax payments, and their distribution between budgets of different levels for each country are analyzed in detail. A comparative analysis revealed both similarities and differences between the Russian and German tax systems. The results of a comparative analysis of the tax systems of Germany and Russia can be further used to study the features of the tax systems of Russia and Germany and improve the tax system of the Russian Federation.

Keywords Taxes · Tax system · Collection · Budget · Tax principles · Tax code of the Russian Federation

K. Y. Reshetov (✉) · V. I. Mysachenko
National Institute of Business, Moscow, Russia
e-mail: konstantvip@yandex.ru

V. I. Mysachenko
e-mail: mysviktor@yandex.ru

K. Y. Reshetov · A. S. Mikhailova
Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
e-mail: anya_mihailova33@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_19

1 Introduction

A harmoniously constructed system of collecting and using "mandatory, individually gratuitous payment levied from the organizations and physical persons" [6] contributes to the balancing of the federal budget of any country that provides favorable conditions for the development of the economy, ensuring the success of the national economy. In this regard, modern states attach great importance to the formation of an effective fiscal system, a legitimate policy whose principles determine economic, social, law enforcement, and other state functions.

A favorable tax and legal situation in the country guarantees the economic well-being of citizens, so modernization of tax systems holds a special place in the globalized world economy. In order to update the tax mechanism successfully, it is important to refer to the foreign experience of tax regulation. Developed countries, where the determining factor in the development of the state is taxes, which make up a significant part of the federal budget, are of particular interest.

2 Materials and Methods

An analysis of foreign and domestic experience regarding the formation of an effective tax system has been carried out as part of the study. General scientific methods were used as research tools: analysis and synthesis, systematization, statistical generalization to substantiate theoretical provisions, and practical recommendations aimed at improving the tax system and increasing the effectiveness of tax policy instruments of the Russian Federation.

3 Results

One of the highly developed countries with a market economy is Germany, in which a complex mechanism of the tax system, as a result of constant harmonization and changes, has been functioning for many years, providing a high degree of social protection for German citizens. It is worth noting that among other developed countries, Germany occupies one of the leading positions in terms of tax rates. According to studies conducted by the Organization for Economic Cooperation and Development (OECD) in 2016, Germany ranked second in terms of taxation among industrialized countries. On average, per employee in 2016, the amount of taxes was 49.4% of the salary received [1]. This tax system allows for a high level of social protection of citizens, which is directly a result of the high level of economic development of the state as a whole.

Germany is a federal state with a complex and extensive system of taxation, which consists of three levels—federal, land, and community taxes. The country has more than 40 types of taxes, which are one of the government's main sources of income, as well as government spending. In 2017, taxes accounted for more than 90% (€309.4 million) in the German federal budget revenue structure, with total revenues of €330.4 billion and expenses of €325.4 billion [7]. One of the main tasks of the German state is to distribute the federal budget in such a way that the country's revenues are equal to expenses, which is observed in the report of the German Ministry of Finance for 2017 [2].

Tax revenues are considered by the state as one of the main tools for influencing the development of the country's economy. The state requires an appropriate contribution to finance the main state tasks aimed at providing protection and a decent standard of living for citizens, including free education, preferential medical care, and high social benefits for unemployment. The main principle of tax policy is fair taxation, namely the equality of tax payments and services provided.

The principles of the tax system that still exists in the German state were laid down in the postwar period by the statesman and German Chancellor Ludwig Erhard, who shared the desire of citizens to reduce the tax burden. According to him, the way in which this reduction in payments is achieved is of particular importance: "If we managed to achieve the desired stabilization costs and the development productivity grew at the same pace, it would be easy to imagine and calculate possible tax" [5]. Among the most important principles of L. Erhard, the following are distinguished:

- taxes should be as low as possible, and their collection should be economically feasible;
- taxes should not impede competition;
- taxes should be consistent with structural policies and aim for a more equitable income distribution;
- the tax system should be based on respect for the privacy of the taxpayer and the preservation of trade secrets;
- the tax system should exclude double taxation;
- the amount of income should correspond to the size of public services, including the protection of a citizen, and all that a citizen can receive from the state.

The Basic German Law (Grundgesetz für die Bundesrepublik Deutschland) and the Tax Collection Act (Abgabenordung) are the fundamental laws that define the general conditions and principles of taxation in the country, as well as the procedure for calculating tax payments and their distribution between the federation, states, and communities. In accordance with the territorial division, administrative entities (Gebietskörperschaften) generate their tax revenues and carry out economic activities independently of each other. However, all state tasks related to general economic and political activities in the country should be distributed between the federation and the states, as enshrined in the Basic Law of Germany Art. 104a-108 [4].

The federal and regional systems, in accordance with their main responsibilities, including the distribution of tax payments, independently form a budget structure of their own level and, accordingly, the expenses incurred in performing certain functions are carried out separately. Communities also form local budgets, in which funds are used to perform social functions. However, the leading place in tax legislation is occupied by the federation. Such a territorial division assumes the following structure of tax distribution: customs duties, transport tax, vehicle tax, and income tax are classified as federal taxes; to land belong taxes on property, inheritance, beer, tax on winnings; to the community belong land, fishing, excise taxes, luxury tax [3].

In Germany, the largest tax revenues are distributed among the budgets of territorial units. Thus, personal income tax is distributed as follows: 42.5% of the proceeds go to the federal budget, 42.5% to the land budget, and 15% to the local [7]. At the same time, corporate tax and value-added tax are distributed equally between the federal and land budgets. Such coordination should not allow overloading of taxpayers and ensure equal living conditions [4].

Income tax is one of the main taxes in Germany; in 2017, its share in the structure of tax revenues was 45%—€330.4 billion, with total revenues of €734.5 billion [8]. The tax base for calculating income tax is reduced by the cost of living.

The German tax system uses criteria for individual calculation of the tax burden, taking into account personal circumstances and the economic situation of citizens. In this regard, a progressive tax structure is used: citizens with high-income pay a large share of the state budget. In order to calculate the amount of income tax, solidarity tax, and church tax, tax classes are used that determine the amount for social payments. There are six classes of taxes that are assigned to everyone working in Germany. In accordance with them, the tax-free amount is determined (Steuerfreibeitrag):

- 1st class includes single citizens—unmarried or divorced;
- 2nd class includes people raising minor children single-handedly;
- 3rd class includes people who are married or in a civil partnership who have not chosen class 4, as well as widowers (widows);
- 4th class includes people in a marriage or a civil partnership, recommended for people with the same income;
- 5th class is assigned automatically to people whose spouses have received 3rd tax class;
- 6th class is optional and is issued to individuals for additional tax cards if the taxpayer works on several jobs.

Depending on the tax class chosen by each of the family members, a certain model is formed, according to which the amount not taxed is set [9]. Along with this class division, there is a living wage, which is also not taxed. The cost of living is determined by the government every two years, and, in accordance with the report of the Ministry of Finance for 2018 (Bericht über die Höhe des steuerfrei zu stellenden Existenzminimums von Erwachsenen und Kindern für das Jahr, 2018 (11. Existenzminimumbericht)), the living wage amounted to €8652 for unmarried citizens and €17,304 for married couples, with a €4608 tax deduction for children [7].

Germany is one of the few countries where, in addition to vertical income alignment, horizontal alignment is also used, suggesting that highly profitable lands like Württemberg and Bavaria transfer part of their financial resources to less developed lands. This interaction of territorial units has developed as a result of the long development of the tax system. It allows for a high standard of living in the country as a whole.

The tax systems of Germany and Russia are similar. Since Russia is a federal state, it also uses three tax levels: federal, regional, and local. However, in the principles of their structure and orientation, the actions of the system differ from each other. First of all, it is worth noting that the main goal of the tax system of Russia is to reduce the budget deficit. The implementation of this priority area of the tax system is the result of a lack of a connection between the current taxation and the conditions of the real economy. Strict mandatory payment conditions for both legal entities and individuals do not provide for the individual characteristics of subjects. The consequence of this policy is the fact that there is no relationship between the tax system and the development of economic activity in the country.

As in the German tax system, in the Russian one, taxes are assigned one of the main roles in budgeting. In these systems, tax payments are considered the main sources of state revenues and expenses. Both countries have the main tax law—Tax Code.

On the example of the German system, it can be noted that the successful functioning of tax policy is implemented, first of all, due to the optimal provision of social interests of various sectors of society. Such harmonization of the functioning of the main regulator of the economy, the tax system, can guarantee the social balance of society. At the moment, in the Russian economic system, this principle is not fully implemented, since one of the significant problems of modern Russian society is economic inequality among citizens. An indicator of such inequality is the Gini coefficient, which expresses the uneven distribution of income in society, manifested in the deviation of the actual distribution of income in society from absolutely equal between citizens of the state. In 2016, the Gini coefficient in Russia equaled to 41.6, while in Germany, it was 30.1 [8]. Such a difference in indicators proves that the current tax system strengthens inequality due to the fact that, first of all, the most important function of the tax system is distribution. Taxation should be aimed at eliminating imbalances in household incomes [10].

The social stratification of a company by income can be reduced using a progressive taxation system that ensures social justice by increasing the tax rate depending on the growth of taxpayer income. Such a scale of taxation is actively used in many Western countries, including Germany. In Russia, the tax system is proportional: All taxpayers are equal to each other, and they pay the same proportions of their income to the budget. The tax rate on personal income is 13%, and it is 35% in relation to winnings, prizes, and interest income on deposits with banks [6]. The use of such a tax structure is a significant drawback since the main task of the tax mechanism is to distribute income between different types of activities optimally. This provides an acceptable economic structure that meets the needs of the market demand, which is achieved through progressive taxation.

One of the main taxes in Germany is the income tax, which makes up the largest share in the country's budget; in Russia, the tax on personal income is considered an analog of such a tax, which takes the second place after the corporate income tax.

Along with a high-income tax rate, a living wage has been introduced in Germany, which is not taxed. However, in reality, the Tax Code of the Russian Federation does not provide for a tax-free minimum. In German tax law, there is a criterion of an individual tax burden, which is the maximum permissible: spouses and large families pay a lower tax amount than childless and single citizens. In Russia, it is necessary to introduce such tax rates as are capable of ensuring a fair redistribution of income. A beneficial effect on the redistribution of the tax burden between legal entities and individuals will have a return to the progressive taxation of personal income.

It should also be emphasized that, while in Germany, the share of indirect taxes is decreasing, in Russia, it is increasing. This happens due to the fact that the Russian tax system has an inflationary character. This trend indicates a disadvantage in taxation, expressed in the desire to increase tax revenues.

The Russian tax system is characterized by instability from the legislative point of view: the Tax Code is often amended, which negatively affects the production strategy of enterprises. The German system, despite the high tax rates and a large number of taxes, is stable. Amendments to the German Tax Code are mainly introduced in connection with the recommendations of the European Union regarding tax optimization.

4 Discussion

It is difficult to adapt foreign experience to Russian conditions, but the analysis and identification of positive results of the interaction of structural elements of the German tax system, as well as their implementation in the Russian tax administration, will increase the tax potential, which will directly ensure the prosperity of our economy. Nowadays, one of the main tasks of the Russian economy is to improve the tax policy of the country, which will eliminate the shortcomings of the existing system and also increase its effectiveness, which will directly provide positive results in the economic and social sphere. The main goal of the modern tax system of Russia is to create tax incentives that ensure increased labor productivity, create favorable conditions for the development of market institutions and mechanisms, update fixed assets of enterprises, and reduce the overall tax burden. It seems that the innovative development of taxation tools will ensure a favorable socio-economic development of society and increase the investment climate in Russia.

5 Conclusion

The tax system of Russia has features in common with the German system, which proves the relevance of studying the latter and does not exclude the possibility of applying tax practice to one of the leading developed countries in the Russian Federation. At the same time, tax reform is a dynamic process; therefore, further analysis of foreign taxation experience should be conducted.

References

1. Böcking, D.: Deutschland ist Zahl-Vizeweltmeister. Retrieved from https://www.spiegel.de/wirtschaft/soziales/steuern-deutschland-ist-vizemeister-bei-der-abgabenlast-a-1142772.html (2017)
2. Federal Ministry of Finance of Germany: Vorläufiger Abschluss des Bundeshaushalts 2017. Retrieved from https://www.bundesfinanzministerium.de/Monatsberichte/2018/01/Inhalte/Kapitel-3-Analysen/3-7-Vorlaeufiger-Haushaltsabschluss-2017.html (2018)
3. Federal Ministry of Justice and Consumer Protection of Germany: Abgabenordnung. Retrieved from https://www.gesetze-im-internet.de/ (2018)
4. Federal Ministry of Justice and Consumer Protection of Germany: Grundgesetz für die Bundesrepublik Deutschland. Retrieved from https://www.gesetze-im-internet.de/gg/BJNR000010949.html (2019)
5. Leonova, N.G.: History and theory of taxation. TOGU, Khabarovsk (2016)
6. Russian Federation: Tax Code of the Russian Federation. Retrieved from https://www.consultant.ru/document/cons_doc_LAW_19671/ (2008)
7. Sollbericht: Ausgaben und Einnahmen des Bundeshaushalts. Retrieved from https://www.bundesfinanzministerium.de/Monatsberichte/2018/08/Inhalte/Kapitel-3-Analysen/3-1-Sollbericht-2018-Ausgaben-Einnahmen-Bundeshaushalt.html (2018)
8. Sozialpolitik aktuell. (n.d.): Retrieved from https://www.sozialpolitik-aktuell.de/
9. Steuerklassen. (n.d.): Retrieved from https://www.steuerklassen.com
10. Stolypin Growth Economy Institute: Income of Russian citizens—a comparison with the world. Retrieved from https://stolypin.institute/wp-content/uploads/2018/04/issledovanie-ier_dohody-grazhdan.pdf (2018)

The Estimation of the Response Time of Beekeeping Influence on the Management of Elements of Agricultural, Socio-economic, and Ecological Systems, Based on the Methodology of Real-Time Systems

Igor N. Mishin

Abstract The focuses on the problem of assessing the response time of the impact of manageable variables on the elements of agricultural, socio-economic, and environmental systems. The model was built in the form of a hierarchical open system with the elements of an information network and feedback to assess the response time of the impact of beekeeping, pollination, science, and education on the controlled parameters. The methodology of real-time systems was used with a limitation of time parameters. A formula has been developed that makes it possible to estimate the response time as a ratio of the following main indicators described in the paper in details. The estimation of the minimum and maximum response times of the system for achieving sustainable development ranges from two to five years and does not go beyond the established time limits determined by the model. The paper proposes solutions to reduce the response time of the system and to increase the speed of information exchange. In particular, the author discussed how to increase the level of digitization of rural areas; the placement of legislative information in social networks; the personalized SMS distribution of information; and how to reduce the number of priority social and economic tasks.

Keywords Beekeeping · Pollinators · Modeling · Environmental systems information flows · Real-time systems · Economic systems · Response time

---

I. N. Mishin (✉)
Smolensk State Agricultural Academy, Smolensk, Russia
e-mail: igo21vek@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_20

1 Introduction

The 2030 Agenda for Sustainable Development determine 17 priority goals that can be achieved on the basis of the complex interaction of various political, social, economic, and environmental factors, elements, and systems, including health science and education [13]. At the same time, a number of factors that have a significant impact on the sustainable development of systems, for example, beekeeping and pollination, are underestimated.

Beekeeping as an element of agricultural production makes a significant contribution to job creation, ensuring food security, and increasing yields for 87 of the world's leading food crops. Pollination is a prerequisite for cultivating 41 agricultural crops [6]. A decrease in the number of pollinators, particularly due to the collapse of bee colonies, leads to large economic losses and an increase in the prices of nuts, fruits, vegetables, and other food products [1]. Honey bees and pollination as elements of ecosystems, including urban ecosystems, affect the biodiversity and sustainability of natural and agricultural biocenoses while providing the best-quality human environment [3, 5, 9].

Thus, at least five goals of the concept of sustainable development (goals 2, 8, 11, 12, and 15) are directly or indirectly related to beekeeping, which is one of the governing factors for ensuring economic growth, employment, a healthy lifestyle, food security, the preservation of biodiversity, the promotion of sustainable agriculture, and the addressing of a host of other challenges.

Considering the goals of sustainable development, there is a need to correctly determine the assessment of the regulatory impact, the timing of achieving the goals, and, in particular, the solution to the problem of assessing the time of the influence of individual factors on certain control actions, such as innovative technologies, science, infrastructure, and economic factors, on achieving stable response and steady-state systems.

2 Materials and Methods

Given that beekeeping is one of the tools for managing the development and maintaining the stability of various elements of agricultural systems and the associated socio-economic and ecological systems, there is a problem of estimating the response time of individual elements, objects of systems, and systems in general after the controlling action on them of certain factors related to beekeeping. There is a number of models of agroeconomic systems [7], including models evaluating the influence of direct and indirect factors regulating the honey bee population and beekeeping [11], the mutual influence of beekeeping (through pollination), regional management methods, and landscape conditions [5], along with several others. However, these models and methods do not evaluate the response time - the time of occurrence of the effect as a result of the interaction of beekeeping objects with different systems.

The evaluation of response time is also required both at the upper levels of the system for the effectiveness of the implementation of a program, investment efficiency, and at lower levels of the system and its individual elements to estimate the time for obtaining the effect of using control factors, for example, increasing the farmer's income, the emergence of new jobs, and supporting biodiversity in ecosystems.

In order to estimate the response time, we will use the methodology used in information distributed systems of real-time. Such systems are characterized by compliance with relatively strict time limits for information exchanges with external processes and timely execution of many tasks. The response time of a task (the assessment of feasibility) in the simplest case is determined by the sum of the individual tasks, taking into account the time, priority of their implementation, and feedback recursive [8, 10].

The solution to the problem of assessing the response time of the impact of beekeeping on the sustainability and development of elements of agricultural, socioeconomic, and environmental systems can be carried out in accordance with the model presented in the form of an open system with elements of an information network and information feedback (Fig. 1).

The central subsystem of the model is determined by a set of interconnected elements: beekeeping, focused on the provision of services (pollination) and the production of beekeeping products as part of the socio-economic system, and honey bees as the basis of beekeeping and part of agricultural and ecological systems.

The dynamics of the model are affected by the input control factors of stability (u_i), which include scientifically-based innovative technologies for intensive beekeeping and pollination, a pollinator protection system, and a multi-level system of education. The model is also influenced by external control actions v_i, which, in the form of information flows, pass through the system and are determined by state policy and state programs in the field of social, economic, and regional planning and development.

Using the input control factors, one can purposefully act on the elements of the system, changing the controlled stability parameters (system response, y_i). For example, the use of intensive beekeeping technologies leads to an increase in the number of jobs, an increase in the production of horticulture and beekeeping (socio-economic systems), and an increase in pollination intensity and the conservation of biodiversity and the sustainability of biocenoses (ecological systems).

An integral part of the model is horizontal and vertical information flows (k_i) interacting with all elements of the model, including feedback, caused by a relatively high level of informatization and a high intensity of information exchange via the Internet in the "Science—Innovative Technologies—Education—Production—Beekeepers" chain.

This is due, in particular, to the intensive growth in the number of online information resources in the field of beekeeping, including the growth of online forums and professional communities in social networks, which ensures a significant intensity of information exchange in horizontal information flows within the developed model.

Considering the presented scheme as an information model, it is important to evaluate the possible response time of system elements to control actions. It is important

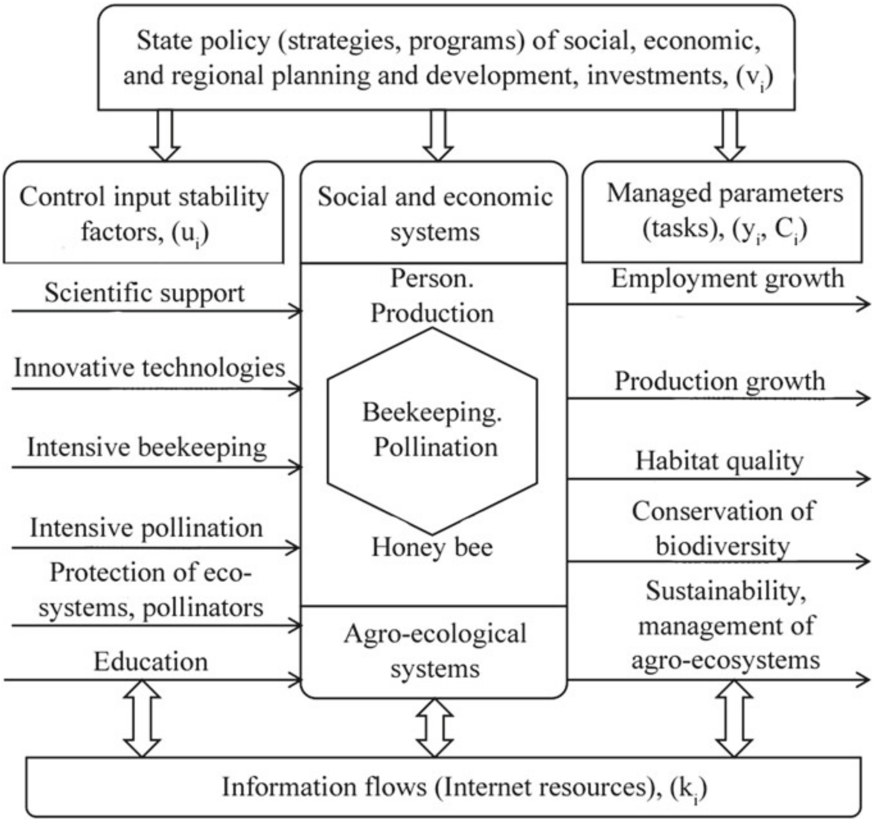

Fig. 1 A model of an open system of the influence of beekeeping and pollination on the management of elements of agricultural, socio-economic, and environmental systems

to evaluate the time it will take the adopted regulatory documents, innovative technologies, training of specialists, and application of various measures to change the output-controlled parameters and achieve the tasks.

In order to estimate the response time of the system R or, in other words, the response time of system elements under the influence of the control factors (v_i, u_i) on the controlled parameters (y_i), in particular, to estimate the time for achieving the objectives specified in the model (for example, increasing production, or biodiversity management), it is proposed to use the following ratio (developed based on the methodology of real-time systems), taking into account the time of information exchange in the system (Formula 1):

$$\mathrm{R}(y_i) = \frac{\mathrm{U_i}}{\beta_u \mu_u} + \frac{\mathrm{V_i}}{\beta_v \mu_v} + \mathrm{C_i} + \sum_{j=1}^{n} p\mathrm{C_j} + \mathrm{B_i}, \tag{1}$$

where C_i—the task execution time; C_j—the delay time (determined by the execution time of higher priority tasks); *p*—the coefficient determining the relationship (feedback) between R and C_j; B_i—task blocking period—the time to wait for the necessary resources and investments for completing the task; U_i and V_i—time for completing previous tasks or making management decisions at the appropriate level; β_u, β_v—the factors that determine the delay in the emergence of control solutions or the performance of previous tasks, including the emergence and implementation of innovations at the appropriate level; μ_u, μ_v—the coefficients determining the delay in receipt of the necessary information to the performer of the work, including those caused by information noise at the appropriate level.

3 Results

Let us estimate the response time of the influence of the controlling factor—the development of beekeeping (the use of innovative technologies of beekeeping and pollination)—as a set of different management and technological solutions to achieve certain socio-economic and environmental parameters, and their sustainable development in a particular farm (district), by assessing the possible value of the variables for Formula (1).

The initial conditions are existing programs for entrepreneurship support, subsidizing loans for farms (peasant farms), agricultural development, and others (D_i).

When estimating the time of making management decisions (V_i), it should be taken into account that a certain delay is characteristic of this indicator in socio-economic systems, which can be traced when transmitting information from the upper level (about the availability of management decisions and the possibility of their use). As a rule, such control information is posted on official websites and often is drowned in informational noise, in a stream of various news and other legislative information. The user (usually a rural resident) does not always possess the necessary qualifications to search for the necessary information resources and their timely use. Accordingly, the assessment of the indicator V_i can vary from one day (from the moment of publication, subject to tracking the necessary information) to $V_i > D_i$ (longer than the implementation period of the corresponding program) with $\beta_v = 1$, $\mu_v = 0.2$–0.6 (there exists a management decision, and information on the implementation mechanism of which is difficult to find); the average delay time is 6–7 months.

The next indicator, $B_{i,}$ is the waiting time for the appearance of the necessary resources (that is, the performer's participation in any support program for farmers or obtaining a loan) consists of the time spent collecting documents, participating in the competition, considering the application, and obtaining the necessary resources. It currently ranges from 1 to 6 months.

The indicator, $U_{i,}$ determines the amount of time taken to complete the previous tasks, in this case, the introduction of various beekeeping and pollination technologies, including innovative high-tech technologies, technological information promotion, and advanced training. Moreover, given the high number of bee colonies in the country, as well as the high intensity of information exchange among beekeepers, there is the possibility of relatively wide testing of technologies simultaneously on a large number of apiaries and a quick exchange of experience, including via a training video. Simultaneously, beekeeping is characterized by the use of traditional (obsolete), inefficient, energy-intensive technologies and equipment, so the U_i indicator can vary from 3 to 4 months (time sufficient to introduce any technology over the summer period) to ten or more years.

The value of the coefficient μ_u (determines the delay in the receipt of the necessary information by the performer of the work) should be set high enough; it is associated with a limited number of descriptors in beekeeping $\mu_u = 0.8$–0.9, allowing one to find, relatively quickly, the necessary technological, scientific, and educational information in the beekeeping field. The value of the coefficient β_u (determines the delay in the appearance of management decisions and the solution of previous problems) can vary significantly for different types of systems: for socio-economic systems $\beta_u = 0.7$ (insufficiently high level of implementation of innovative technologies); for ecological systems, $\beta_u = 0.1$. (In fact, there are no governing decisions to protect pollinators and their use in biodiversity conservation in Russia.)

To the greatest extent, the response time increases the indicator C_j—the execution time of more priority tasks. Unfortunately, state agricultural development programs in Russia do not support the beekeeping and pollination necessary to achieve certain indicators of the implementation of state programs on purebred breeding, seed production, crops under glass, oilseeds, and others.

Let us evaluate the total response time of system elements: for example, for solving the problem of apiary development to increase the production of beekeeping products (crop production) using innovative technology, taking into account the absence of higher-priority tasks (time $C_j = 0$).

Then the minimum response time will be (at maximum β and μ coefficients) from 3 to 18 months, an increase in production either in the current season or towards the end of the next season; the maximum response time will be (at minimum β and μ coefficients) about 42 months. Additionally, in order to achieve the sustainability of the system, it is necessary to add at least 2 years to the response time for socio-economic systems and 4–5 years for ecological systems.

4 Discussion

The developed model based on the methodology of real-time systems shows the possibility of using beekeeping resources, innovative high-tech technologies, pollination, and education to carry out a controlled effect on the elements of agricultural, socio-economic systems, and environmental indicators in a relatively short period of time. The resulting model, by its structure, solves problems close to the problems of a systematic approach to the development of agriculture and food security [12], as well as environmental network analysis (ENA), based on the study of material-energy-information networks by focusing on interactions between environmental and economic components of the system that are not obvious from direct observations [4].

Thus, in the developed model, as in the ENA network model, considering the place of beekeeping and pollination in regional social and agricultural systems, sustainable relations are observed. They are characteristic of network models, in the form of positive direct and reverse information and regulatory relations, when, for example, an increase in the number of bee colonies as an element of farming leads to an increase in incomes, yield, and productivity of entomophilous plants, and, as a result, again, to an increase of incomes not only of the farmer (the owner of the bees) but also of neighboring farms, and, as a general consequence, to the possibility of a further increase in the number of bee families.

The relationships (direct and inverse) considered in the model, control actions, assessment of the response time to managerial and technological decisions in the system, "Science—Innovative Technologies—Education—Beekeeping—Pollination—Jobs—Products—Habitat Quality—Biodiversity," are closely intersected and complement the models [5, 11] of interactions of beekeeping with various economic and environmental factors.

The developed model, as well as the above network and factor models, show that to control the development and stability of systems, on the one hand, an increase in the level of organization of the system is required. On the other hand, an increase in the intensity of information exchange and a decrease in the response time of the system to control actions is needed.

Analyzing the received model and considering beekeeping as one of the factors of management of development of various systems and their elements, reduction in time of response of the system to the influences arriving from various hierarchical levels with the observance of external time restrictions (for example, a term of implementation of any program) becomes an important problem. Obviously, to reduce the response time (R), it is necessary to increase the indicators and coefficients (U_i, V_i, β, and μ), as well as to reduce the delay and waiting time (C_j, B_i), including at different stages of information exchange. In order to solve this problem, a number of possible solutions are proposed.

Thus, an increase in the coefficients μ (a decrease in the delay in the receipt of necessary information by the contractor) is achieved by increasing the digitalization level of rural areas, including providing access to high-speed Internet, as well as by training managers, specialists of agricultural enterprises and farms to work with certain Internet information resources, for search and timely access to relevant information.

An increase in the β coefficients, as well as a decrease in the delay time for solving previous problems, the appearance of control solutions, and the waiting time for resources, investments (U_i, V_i, B_i), are associated with two main streams: the first stream is determined by the efficiency of information transfer from the top level to the performer about the presence of any solutions or innovative technologies; the second stream transfers information from the lower to the upper levels, determines the need for management decisions or for investments (investors) to solve problems, for example, to introduce some kind of innovative technology. Improving the efficiency of transmitting information for the first stream is possible by posting legislative information on professional forums in social networks (the highest rate of dissemination of information), and sending information through personalized SMS, for example, on farmer support programs among agricultural producers. This approach has been shown to be effective in disseminating reports of weather deterioration and scientific and socially significant information [2]. Improving the efficiency of information transfer for the second stream is associated with the responsiveness of managing organizations (structures) to social, economic, and environmental problems arising at lower levels and timely and prompt response to modern challenges, in particular through seminars, meetings, and conferences with the participation of legislative and executive authorities and agricultural producers. Venture capital funds and a crowdfunding platform could be created to implement innovative agriculture projects and to increase the efficiency of the search for investments (investor).

Reducing the delay time C_j (the time to complete more priority tasks) is largely dependent on the subjectivity of determining the priority of tasks, especially in multifactor systems. Often, subjectively selected priority tasks are performed to the detriment of other equally or more important tasks. Accordingly, for reducing the delay time, it is necessary to reduce the number of priority tasks, both social and economic, so that they do not increase the delay time for performing related tasks.

The most difficult thing is to reduce the response time in ecological systems due to the length and complexity of the processes in biosystems, as well as manufacturers and officials' lack of knowledge (supplemented by low interest) about environmental problems and their solutions, for example, the impact of intensive pollination on the quality of the human habitat, biodiversity, and agricultural production. This problem, in particular, is solved by increasing information exchange in the system "Science—Education—Production—Governing Bodies."

5 Conclusion

The assessment of the response time of management decisions, made on the example of using the capabilities of beekeeping, showed that the transition time of system elements to a stable state, based on the use of innovative high-tech technologies, education, various technological and management decisions, calculated using the methodology of real-time systems, is estimated as two to five years.

Such terms correspond to the time for achieving the target indicators for various state programs in Russia, as well as the payback period for investments. Moreover, the response time significantly depends on a number of factors: the delay time due to the performance of more priority tasks; the waiting time for the appearance of the necessary resources and investments; the time taken to complete the previous tasks;

the services performed or management decisions made at the appropriate level; and the time taken for the control information to pass through, the possibility of its detection in the information noise, and its receipt by the performer of the work.

The developed model allows us to estimate the response time of the elements of agricultural, socio-economic, and environmental systems to control actions, not only for beekeeping, but also for other similar systems. Reducing the response time of the system to control actions is achieved by increasing the speed and volume of information interactions between hierarchical levels, including the speed of the information transfer to the upper levels of the hierarchy, increasing the intensity of information exchange in the system "Science—Education—Production—Management Bodies," and raising the level of digitalization, especially in rural areas. This is also achieved by increasing the computer and information literacy of managers and specialists at all levels of the system.

References

1. Amadeo, K.: Colony collapse disorder and its impact on the economy. Retrieved from https://www.thebalance.com/bee-colony-collapse-disorder-facts-and-economic-impact-3305815 (2019)
2. Bakshy, E., Rosenn, I., Marlow, C., Adamic, L.: The role of social networks in information diffusion. Retrieved from https://arxiv.org/abs/1201.4145 (2012)
3. Bennett, A.B., Lovell, S.: Landscape and local site variables differentially influence pollinators and pollination services in urban agricultural sites. PLoS ONE **14**(2), e0212034 (2019). https://doi.org/10.1371/journal.pone.0212034
4. Fath, B.D., Scharler, U.M., Ulanowicz, R.E., Hannon, B.: Ecological network analysis: network construction. Ecol. Model. **208**, 49–55 (2007). https://doi.org/10.1016/j.ecolmodel.2007.04.029
5. Kennedy, C.M., Lonsdorf, E., Neel, M.C., Williams, N.M., Ricketts, T.H., Winfree, R., Bommarco, R., Brittain, R., C., Burley, A.L., Cariveau, D., Carvalheiro, L.G., Kremen, C.: A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. Ecol. Lett., **16**(5), 584–599 (2013). https://doi.org/10.1111/ele.1208
6. Klein, A.-M., Vaissière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Tscharntke, T.: Importance of pollinators in changing landscapes for world crops. Biol. Sci., **274**, 303–313 (2007). https://doi.org/10.1098/rspb.2006.3721
7. Kormakov, L.F., Volkova, N.G.: Modeling as a tool of scientific research of agro-economic systems. Econ., Work., Manag. Agric., **5**(38), 41–44. Retrieved from https://elibrary.ru/item.asp?id=35384777 (2018)
8. Liu, J.W.S.: Real-Time Systems, pp. 115–189. Prentice Hall, Upper Saddle River, NJ (2000)
9. Makarov, Y.I., Mishin, I.N., Prudnikov, A.D.: Beekeeping as an environment-forming factor in the system of rational use of natural resources. Retrieved from https://beejournal.ru/priroda-nash-dom/3297-znachenie-pchelovodstva-v-prirodopolzovanii (2004)
10. Nikiforov, V.V., Shkirtil, V.I.: Response time estimation chains in distributed real-time system. SPIIRAS Proceeding, **4**(23), 134–156 (2012). https://doi.org/10.15622/sp.23.8
11. Roulston, T.H., Goodell, K.: The role of resources and risks in regulating wild bee populations. Annu. Rev. Entomol. **56**, 293–312 (2011). https://doi.org/10.1146/annurev-ento-120709-144802

12. Shutkov, A.: System approach in a program goals management. Econ. Agric. Russ. **5**, 6–17 (2014)
13. United Nations: About the sustainable development goals. Retrieved from https://www.un.org/sustainabledevelopment/sustainable-development-goals (n.d.)

Digital Challenges and Prospects

The Authorization of Russia and Developing Countries in Global Digitalization

Elena B. Krylova, Tatyana V. Podsvetova, and Evgeny N. Soloviev

Abstract The paper analyzes the level and place of Russia and developing countries in global digitalization. The presented six Federal projects of the Russian Federation on the implementation of the national program in the development of digital economy give reasons to believe that Russia will not remain an outsider in the digital space. However, the allocated financial resources still fall short of the level of developed countries. New trends of advanced development of digital economy in the countries in comparison with GDP growth rates are discussed. The multi-speed mode of digital economy development in developing countries is defined, which threatens the digital divide and deindustrialization of the least developed countries. The classification scheme of the distribution of countries by the level of development of the digital economy and the likely digitalization scenarios of Russia and developing countries are also discussed by the authors.

Keywords Digital economy · Digitalization · Developing countries · Federal digital economy projects · Russia

1 Introduction

In the context of the rapid development of the digital economy, many countries with emerging markets will soon face the challenge of being ready for electronic commerce, trade logistics, the development of global systems, and Internet security.

Therefore, the study of the opportunities and risks of the digital transformation of the real economy, the rapid increase in its share of digital products and services, new forms of business based on digital technologies is of paramount importance.

E. B. Krylova · T. V. Podsvetova (✉) · E. N. Soloviev
Moscow University for the Humanities, Moscow, Russia
e-mail: tvpodsvetova@mail.ru

E. B. Krylova
e-mail: elenaborisovna@yandex.ru

E. N. Soloviev
e-mail: s140145@gmail.com

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_21

There are many indices, indicators, and ratings developed by international economic organizations and consulting structures that determine the development level of the digital economy in countries and its individual components. This has been expressed in tabular and graphical forms and published in the open press. Therefore, as part of this study, we will give an overall rating score. The analysis of the situation of Russia and developing countries and the problem of their integration into the global digital economy is the purpose of the study.

2 Materials and Methods

In this work, we used materials from digital economy studies conducted within the framework of international economic organizations—the United Nations, the World Bank, the Organization for Economic Cooperation and Development (OECD), and the United Nations Conference on Trade and Development (UNCTAD); consulting agency Boston Consulting Group (BCG); analytical materials of national scientific institutions (the Institute for the Study of Emerging Markets of the Skolkovo Business School, the National Research University Higher School of Economics), official materials of the national program and federal projects of the Russian Federation on the digital economy, as well as conference proceedings on these issues, including the World Economic Forum.

The system approach, comparative analysis, and synthesis, and probabilistic-statistical methods are used.

3 Results

UN analysts ranked the countries with the most developed digital economies. The top ten countries included: Iceland, the Republic of Korea, Switzerland, Denmark, Great Britain, Hong Kong (China), the Netherlands, Norway, Luxembourg, and Japan. Russia took 45th place [9].

As we can see, Russia and developing countries occupy positions far from leading. The situation is somewhat better on the global cybersecurity index—the leading countries here are: Singapore, USA, Malaysia, Oman, Estonia, Mauritius, Australia, Georgia, France, Canada, and Russia. That is, Russia occupies the 10th position in this list; the top ten are also countries with emerging markets.

It is difficult to determine the share of the digital economy in the world economy as a whole because there is still no clear established concept among researchers what parameters should be considered when assessing the digital economy.

Along with the analysis of the difficulties encountered in determining the scale of the digital economy, this paper provides an approximate estimate of the share of the digital economy in the world economy—it makes up about 5% of world GDP and covers 3% of the world labor market for the period of 2018. The digitalization of the economy and markets on a global scale is unevenly distributed. Most of the digital economy is concentrated in the countries of the global North; however, the countries of the global South demonstrate the most significant growth rates [2].

The term “digital economy” first appeared in 1994. At the same time, the first peer-to-peer file-sharing network, Napster, was created by Sean Fanning. Almost simultaneously, electronic commerce appeared [8].

Digitalization is the process of penetration of information and communication technologies (ICT) into a wide variety of industries and markets (including trade, transportation, construction, medicine, etc.).

The digital platform acts as a catalyst for the economy and accelerates operational cycles while reducing transaction costs. Nowadays, it is difficult to assess the consequences of the digital revolution. However, it is clear that they are foreseen at all levels—economic, geopolitical, and social. Business models will change; industries will undergo significant changes.

In 1998, a large study was conducted in the United States to evaluate the digital economy. U.S. President B. Clinton instructed experts to identify possible implications of the digital economy for the future of business and civilization in general.

In Russia, great interest in the digital economy arose from politicians, economists, and entrepreneurs after V. V. Putin’s presidential message in December 2016. It resulted in the development of the national program “Digital Economy of the Russian Federation” (approved on July 28, 2017). The program’s passport was approved on December 24, 2018. The emphasis is on two priority areas. The first presents institutions where conditions will be created for the development of the digital economy: regulatory framework, education, staff, etc. The second contains the basic infrastructural elements of the digital economy: information infrastructure and information security. Six federal projects with the distribution of financial costs have been developed for their implementation [11].

The program implementation period is scheduled until 2024. The total budget is 1634.9 billion. Most of the costs will be directed to the development of information infrastructure (772 billion). The costs of implementing the program are distributed over the years with a cumulative total (Tables 1, 2, 3).

It is assumed that the main result of the program should be the creation of 10 companies that will be the catalysts for high-tech enterprises managing digital platforms.

Table 1 Domestic costs for the development of the digital economy from all sources of the share of GDP in the Russian Federation

Year	Share in GDP (%)
Base value	1.7
2019	2.2
2021	3.0
2024	5.1

Source Passport of the national program “Digital Economy of the Russian Federation”

Table 2 The share of socially significant infrastructure facilities with broadband internet access in the Russian Federation

Year	Internet access (%)
Base value	30.3
2019	45.2
2021	67.5
2024	100

Source Passport of the national program "Digital Economy of the Russian Federation"

Table 3 The share of households with broadband internet access in the Russian Federation

Year	Internet access (%)
Base value	72.6
2019	79.0
2021	89.0
2024	97.0

Source Passport of the national program "Digital Economy of the Russian Federation"

They should form around themselves a system of research teams, industry enterprises, start-ups, creating the infrastructure of the digital economy and developing it.

The implementation of six federal projects for the development of the digital economy gives reason to believe that Russia will not remain an outsider in the digital space. However, the digital divide, in comparison with developed countries, will still exist since the financial resources allocated for the implementation of the program do not compare to the amounts spent by developed countries for these purposes.

Russia, in contrast to developed countries, has chosen a different model for the development of the digital economy. Private companies and investors are the main catalyst and source of financing for digital platforms in the Western model. In Russia, this role was assumed by state structures, represented by state regulators and state corporations, since they possess greater technological and industrial resources than the private sector and are capable of implementing large-scale projects at the national and regional levels (for example, within the framework of the Eurasian Economic Union), not just at the point level.

Let us see how digitalization works in developing countries.

According to the World Bank, the ICT sector accounted for 17% of GDP growth in developing countries over the past ten years. However, its impact was more limited than in the countries of the global North. The larger size of the digital economy in the countries of the global North means that it has had a greater impact on economic growth. For example, McKinsey data show that the Internet provided about 20% of GDP growth in developed economies over the five years to 2011 and more than 10% of growth in the large emerging economies of the BRICS.

The emergence of a new trend in the development of the modern world economy should be noted. The growth rate of the digital economy is ahead of the growth rate of the economy as a whole, and the growth rate of the digital economy in developing countries is higher than in developed countries and equals (according to the World Economic Forum) 15–25% per year [4]. According to UNCTAD, the largest increase in e-commerce is in the countries of the global South. Countries with economies in transition are most likely to create cross-border relationships.

A completely different situation can be seen in some of the least developed countries. The 2017 UNCTAD report on the information economy, "On Digitalization, Trade, and Development," emphasizes the importance of keeping up with the digital divide between developed and developing countries. In developed countries, 70% of the population makes purchases of goods and services online, and in the least developed countries, only 2% [13]. Most small firms in the least developed countries have limited digital participation in production chains, indicating a lack of appropriate communication networks and a shortage of specialists. The use of digital technologies in the least developed countries after the initial introduction is much slower than in other countries due to the digital divide between urban and rural populations, educated and uneducated people, and young and old citizens [5].

The UN calls digital inequality one of the main global problems associated with the development of technology. It is important to pay attention to the fact that digitalization contributes to reshoring (the return to the country of production previously transferred to countries with lower costs). That is, digitalization minimizes the offshoring process that prevailed in the world economy 1960–2010, since the use of robots and other digital technologies in the economies of developed countries reduces labor and logistics costs and promotes the territorial convergence of production and research centers. This can help to slow down the investment process in developing countries, and ultimately deindustrialize them.

Based on the multi-speed digitalization regime of the world economy, five groups of countries can be conditionally distinguished by the level of development of the digital economy. *Leading countries* include countries with the most advanced solutions in the field of digital technology development, such as the Republic of Korea, Denmark, Great Britain, and others.

The *main group* is made up of the most developed countries of the world, including the USA, Japan, Germany, and a number of countries in the European Union. *The third category* is a group of lagging countries, including Middle Eastern countries like Saudi Arabia and the UAE. These are countries that have a high per capita GDP, but the level of digitalization is lower than that of countries with a comparable specific GDP.

The group of *emerging leaders* includes countries whose digitalization level is higher than the level of economic development. China belonged to this group until recently, when it made a digital breakthrough.

The fifth category is *a group of countries with catch-up development to do in the field of digital development.* Russia moved from this group to the peripheral part of the main group of countries, based on the degree of development of the digital economy. Unlike China, which has made a breakthrough in the field of digitalization, Russia has evolved. Considering that the main financial costs when implementing the Digital Economy of the Russian Federation program will be incurred from 2023–2024, the likelihood of accelerating the country's digitalization process is increasing. An important indicator is the reduction of the backlog of Russian regions from Moscow, in terms of digital development, by more than half due to the development of access infrastructures for digital services.

The Boston Consulting Group (BCG) identifies the problematic regions of Russia with the lowest value of the digitalization index of the economy: developing regions—the Urals, some regions of Siberia and the Far East, and regions of central and southern Siberia. The second group includes developing sparsely populated regions (BCG terminology)—sparsely populated regions of the Far East and northern regions—Arkhangelsk, Murmansk, and Tyumen regions, Kamchatka region, and Chukotka Autonomous Okrug. BCG includes Ingushetia, the Chechen Republic, Karachay-Cherkessia, Dagestan, and Kabardino-Balkaria in the group of lagging regions, in terms of their involvement in the digital economy [1].

Possible scenarios for the digital development of Russia are presented as follows. The Venezuelan scenario implies a growing lag behind developed countries. The Asian scenario (Chinese version) implies increasing investment by both public and private sectors not only in basic components, such as infrastructure, but also in promising areas–big data, the development of IT products, and services with high export potential.

Another important aspect of the digitalization of countries with economies in transition is the creation of cross-border relationships in this area. Thus, realizing that the economic competitiveness of the countries of the Eurasian Economic Union (EAEU) depends on the introduction of digital technologies, the following measures have been taken: a road map for the implementation of digital projects has been adopted, including the creation of digital trading platforms; systems for the digital traceability of goods flows and digital transport corridors of the EAEU were created; uniform standards for digitization of tax and customs administration were introduced; etc.

4 Discussion

There is a point of view that the development of the digital economy will weaken the weak (weak referring to individual countries or citizens). Areas of activity where a person is more productive than a machine are becoming fewer and fewer. A precariat, a new social layer of temporary or part-time workers, will appear.

The opposite point of view is that, on the contrary, the development of a digital economy will contribute to the creation of new jobs.

There are different views on the Russian and Western models of digital economy development. It is believed that the Russian digitalization model will have a greater economic effect in the future since the emphasis is on the state financing of the national program and federal projects, which will contribute to the implementation of larger, rather than targeted, projects. Another position is that state financing can provide only the evolutionary path of development of the digital economy in Russia and that this will lead to an even greater lag between the country and the leaders of the digital economy. Without a large-scale attraction of private investors' funds, Russia cannot make a digital leap.

5 Conclusion

Digital inequality is becoming one of the world's major problems. The digitalization of developing countries is uneven. The digital divide of the least-developed countries can lead to a contraction in investment and trade flows to these countries and accelerate the process of resettlement, and the transformation of the labor market under the influence of digital processes will lead to the emergence of the precariat. In contrast, in newly industrialized countries, the pace of development is faster than that of developed economies.

So far, Russia and developing countries are dependent on foreign digital platforms. More than half of the hardware and software account for import purchases.

Unlike China, which made a breakthrough in the field of digitalization, Russia is developing in an evolutionary way. The development model of the digital economy in Russia is different from the western one since these processes are supported by government programs, institutional structures, and budget financing. One of the important problems for Russia is the development of measures to stimulate private sector investment in the development of the digital economy; otherwise the digital divide with developed countries will increase, and accordingly, the competitiveness of the Russian economy will decrease.

The preferences for domestic IT companies by the Government of the Russian Federation, low taxes, and simplified procedures for export foreign exchange transactions suggest that the task of entering domestic companies on the international market will be realized.

The good news is that countries with economies in transition are faster than other countries in creating cross-border relationships for the development of digital projects. Thus, Russia, in the framework of the Eurasian Economic Union, is developing joint approaches to digital trade and developing a roadmap for the development of digital trading platforms using Internet technologies; uniform standards and mechanisms based on digital solutions are being introduced.

There is a positive trend to narrow the digital divide between Moscow and other regions. Currently, the regulatory framework for the development of the digital economy is being clarified, both in Russia and abroad. The growing digitalization of economic activity requires strengthening regulatory functions, both nationally and globally. "Digital wars" force us to accelerate this process. Likewise, the adoption in Russia of the law "on regulatory sandboxes" will allow us to work out new digital projects in a special mode.

The digital revolution cannot happen on its own. In order to maximize the benefits of digitalization, it is necessary to study both the experience of countries' leaders in the digital economy and implementation models in order to optimize strategic national planning.

References

1. Boston Consulting Group: Digital review. Retrieved from https://www.bcg.com/ru-ru/about/bcg-review/default.aspx (2010–2017)
2. Bukht, R., Hicks, R.: Defining, conceptualizing and measuring the digital economy. Bull. Int. Organ. **13**(2), 143–172 (2018)
3. Ciuriak, D., Ptashkina, M.: The digital transformation and the transformation of international trade. Retrieved from https://e15initiative.org/publications/the-digital-transformation-and-the-transformation-of-international-trade/ (2018)
4. Cove, R., Hicks, R.: Definition, concept, and measurement of the digital economy. Bull. Int. Organ. **13**(2), 143–172 (2018)
5. Dahlman, C., Mealy, S., Wermelinger, M.: Harnessing the Digital Economy for Developing Countries. OECD Publishing, Paris, France (2016)
6. Government of the Russian Federation. (2017). Program "Digital Economy of the Russian Federation" (July 28, 2017 No. 1632-r). Moscow, Russia
7. Institute for Emerging Market Research, Skolkovo Business School: Emerging Markets: Four Responses to the Challenges of Growth. Skolkovo Business School, Moscow, Russia (2017)
8. Kozyrev, A.N.: Digital economics and digitalization in historical retrospective. Retrieved from https://medium.com/cemi-ras/%D1%86%D0%B8%D1%84%D1%80%D0%BE%D0%B2%D0%B0%D1%8FD1%8D%D0%BA%D0%BE%D0%BD%D0%BE%D0%BC%D0%B8%D0%BA%D0%B0-%D0%B8- (2017)
9. National Research University Higher School of Economics: Indicators of the Digital Economy: 2018: Statistical Compilation. Higher School of Economics, Moscow, Russia (2018)
10. President of the Russian Federation: Decree of the president "Strategy for the Development of the Information Society in the Russian Federation" (May 9, 2017 No. 203). Moscow, Russia (2017)
11. Presidium of the Presidential Council for Strategic Development and National Projects: Passport of the national program "Digital Economy of the Russian Federation" (December 24, 2018 No. 16). Moscow, Russia (2018)
12. Spartak, A.N.: The implications of digital transformation for international trade. Russ. Foreign Econ. Bull. **5**, 7–23 (2018)
13. United Nations Conference on Trade and Development (UNCTAD): 2017 Information Economy Report, Digitalization, Trade, Development. UN, Geneva, Switzerland (2017)

The Assessment of Territorial Differences in Access and Use of Information and Communication Technologies in the Russian Federation

Svetlana G. Bychkova, Lidiya S. Parshintseva, and Elena B. Gerasimova

Abstract The paper aims to analyze the territorial inequality in the Russian Federation, relying on the leading indicators of the availability and use of information and communication technologies (ICT) by the population and households. The authors critically analyze the existing sources of statistical information and the existing system of indicators characterizing the availability and use of ICT by the population and households in Russia. The indicators used for assessing the digital territorial differences based on the resource-target approach were selected. The degree of unevenness of the digital development of regions within the federal districts and throughout the country as a whole is estimated. The influence of the territorial factor on the formation of indicators of accessibility and ICT use was revealed, and the degree of the relationship of availability and use of ICT in the regions of Russia was assessed. As a result of the analysis, the authors argue that the largest digital gap in the regions of Russia occurs in the affordability of ICT and the availability of skills for its use. At the same time, there is a definite tendency to reduce the digital divide of the regions in these indicators. The variance analysis confirms the importance of the influence of the regional factor on the formation of accessibility and use of ICT by the population and households. The analysis of regional differences in the digitalization processes showed that the problem of digital inequality is most acute, especially in rural areas compared with urban areas. The study of the degree of correlation between accessibility and use of ICT in the regions of Russia showed that the level of skills and knowledge, as well as the material capabilities of the population, which must be taken into account when developing measures to reduce the digital divide, are the essential factors.

S. G. Bychkova · L. S. Parshintseva (✉)
State University of Management, Moscow, Russia
e-mail: lsparshintseva@yandex.ru

S. G. Bychkova
e-mail: svetlana-bychkova@yandex.ru

E. B. Gerasimova
Financial University Under the Government of the Russian Federation, Moscow, Russia
e-mail: egerasimova@fa.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_22

Keywords Digital divide · Territorial factor · Availability · ICT · Regional analysis · Variance analysis · Correlation analysis

1 Introduction

With the development of information and communication technologies (ICT) and the globalization of socio-economic processes, the world community has faced the problem of a significant gap in the availability and use of modern ICT, the so-called digital inequality [1]. At the same time, the gap between the information rich and the information poor is steadily growing, which makes the technologically backward countries even more dependent on developed countries. Given these trends, in 1997, the UN Development Program began to study a new aspect of poverty—information poverty, which measures poverty from the standpoint of the possibility of access by individuals and their various groups to information flows. The Okinawa Charter of the Global Information Society, adopted in 2000, states that "the issue of bridging the digital divide between states and between them have taken an important place in national discussions. Everyone should have access to information and communication networks" [3].

- Widespread use of ICT changes the analytical justification of managerial decisions: the composition of stakeholders and their requirements for the performance of an economic entity are changing; the way of communication between the parties is changing; the object of analysis is transformed; and new phenomena and processes appear that require other approaches to the analysis [4].
- Interest in the problem of digital inequality began to take shape in 1994–1996. The works of a Canadian specialist in business and consulting, Donald Tapscott, and scholars J. Katz, F. Aspden, D. Hoffman, V. Kalsbika, T. Novak, and J. Keller are good examples of that academic interest [6–8, 10].

Tapscott, in his 1994 work, "The Digital Economy: Promise and Peril in the Age of Networked Intelligence," first introduced the concept of the digital economy. In this work, he identifies twelve main characteristics of the new economy: knowledge, digitization, visualization, molecularity, interconnection, disintermediation, convergence, innovation, forecasting, immediacy, globalization, and disagreement. He speaks of the era of network intelligence, which refers to "not only the network interaction of technology … smart machines … but also the unification of people into a network through technology" [10].

- In October of 1995, J. Katz and P. Aspden conducted a random national telephone survey of the population on the topic of Internet barriers. The survey showed a digital divide: Internet users are generally wealthier and have a higher level of education. The main barriers to using the Internet were material difficulties and lack of necessary skills. The survey results were described in detail in a 1997 publication, "Motivations for and Barriers to Internet Usage: Results of a National Public Opinion Survey" [7].

- Fundamental works were followed by a series of publications dealing with various aspects of the considered problem. At the beginning of 2019, the Scopus and Web of Science databases contained 164 and 108 works on this topic, respectively.

The works of Professor van Dijk are of particular interest from the point of view of identifying the causes of digital inequality. In his opinion, there are four types of barriers to the access and use of ICT: (1) The lack of basic digital experiences caused by a lack of interest, computer anxiety, and the unattractiveness of new technology ("mental access"). (2) The lack of computers and network connections ("material access"). (3) The lack of digital skills caused by inadequate user experience and inadequate education or social support ("access to skills"). (4) The lack of opportunities to use ("access to use") [12].

Currently, public policy and public attention are mainly focused on "material access," while, according to many researchers, the problems of access to digital technologies are gradually shifting to a lack of skills and education, as well as a lack of opportunities for using ICT. In this regard, the legitimate question is whether the information support of this problem in Russia is relevant to the challenges of modern times and the scale of territorial inequality according to the leading indicators of the availability and use of ICT by the population and households, as well as the factors that mostly influence its formation.

2 Materials and Methods

The information base of the study is the official statistical data obtained from the results of the Selective Federal Statistical Observation "On the issues of the use of information technologies and information and telecommunication networks by the population" [2, 11]. The methods of grouping and average values, the method of variance, correlation analysis, as well as the tabular method of visual presentation of the research results were used as statistical tools. Microsoft Excel and STATISTICA 10.0 were used to process the primary data.

3 Results

In Russia, the state course on the development of the information society, digitalization of the economy and the social sphere is defined in the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030 and the state program "Information Society (2011–2020)" [5, 9], In each of these documents, the regions of Russia play an important role in the development of the information society and in overcoming the digital divide and digital barriers. It is of particular interest to identify the differences in the availability and use of ICT by the population of the Russian Federation, as well as analyze the impact of regional differences on the variation in the characteristics of access and use of ICT. Besides, the question of assessing the differences in the possibilities of using ICTs by the population of the constituent entities of the Russian Federation living in urban and rural areas was studied.

Based on the possibility of using official statistical information to analyze the digital inequality of the population and households in the regions in the context of urban and rural areas of Russia, four indicators of ICT accessibility were selected from the established system of ICT development indicators (the proportion of households with PCs in the total number of households; the proportion of households with broadband Internet access in the total number of households; monthly subscription fee for Internet access to the average per capita cash income of the population; monthly subscription fee for mobile Internet to the average per capita cash income of the population); three indicators of ICT use (the proportion of the population that has ever used the Internet in the total population, aged 15–74; the proportion of the population using the Internet to order goods and services in the total population, aged 15–74; the proportion of the population using the Internet to receive state and municipal services in electronic form in the total number of people, aged 15–72 receiving state and municipal services) [2, 11]. The use of these indicators is caused by the need to characterize the presence and prevalence of material barriers and barriers associated with a lack of digital skills, respectively.

As a result of the analysis of the main characteristics of the accessibility and use of ICT by the population in the regions of Russia, it was revealed that by specific indicators (the proportion of households with a PC, the proportion of households with broadband Internet access, the proportion of the population that has ever used the Internet, and the proportion of the population using the Internet to receive state and municipal services in electronic form) the stretches of the reviewed period homogeneous in the regions within federal districts and throughout Russia as a whole. Thus, in 2017, the coefficients of variation across the country as a whole amounted to 10.7%, 13.1%, 6.2%, and 21.6%, respectively. In terms of affordability, the regions of Russia differ quite significantly: in 2017, the coefficient of variation for the indicator "Monthly fee for Internet access per month as a % of the average per capita income of the population" was 54.2%, and for the indicator "Monthly fee for mobile Internet per month in % of the average per capita income of the population," it was 46.3%. It is also noteworthy that, in terms of price indicators of accessibility, the subjects of the North Caucasus, Siberian, and Far Eastern Federal Districts are stably heterogeneous throughout the study period. According to the indicator, "The percentage of the population using the Internet to order goods and services," the constituent entities of Russia are also heterogeneous (the coefficient of variation in 2017 was 49.7%), while among the federal districts the largest degree of variation of the subjects is observed in the Southern, Ural, and Siberian federal districts—39.2%, 39.3%, and 42.3% respectively.

The lowest values for two indicators of ICT accessibility ("Specific gravity of households with a PC"; "Specific gravity of households with broadband Internet access") and two indicators of ICT use ("Specific gravity of the population that has ever used the Internet"; "Specific gravity of the population, using the Internet to order goods and services") were noted in the Chechen Republic: in 2017, their values respectively amounted to 39.4%, 32.8%, 69.3%, and 7.5%. In the indicator "The percentage of the population using the Internet to receive state and municipal services in electronic form," the lowest result was in the Chukotka Autonomous Okrug (in 2017—19.2%), while the indicator "Percentage of households with broadband access to the Internet" during the reporting period in this district is also small (in 2016—36.2% (the lowest value in the regions of Russia), in 2017—33.8%). It is interesting that according to the indicator "Monthly fee for Internet access per month as a percentage of the average per capita income of the population," the Chukotka Autonomous Okrug, on the contrary, showed the best results. For example, in 2016, its lowest value was recorded in this region (0.988%), and in 2017, the Chukotka Autonomous Okrug (1.624%) occupied the second place in the considered indicator after the Voronezh region (1.576%).

The best results for the use of all indicators of ICT and two indicators of ICT ("The proportion of households with a PC" and "The proportion of households with broadband Internet access"), in 2017, were shown by the Yamalo-Nenets Autonomous Okrug, being second only in terms of "The proportion of the population using the Internet to receive state and municipal services in electronic form" by 0.1% to the Moscow region.

Given the heterogeneity of the constituent entities of Russia in terms of the availability and use of ICT by the population, it is advisable to identify the influence of regional differences on the formation of selected indicators. The results of the analysis of variance at a significance level of 5% are shown in Table 1.

The results of the variance analysis indicate the significance of regional differences in the population and households for most indicators of the accessibility and use of ICT. However, in 2017, with a 95% probability, the difference in the size of the variance in the federal districts of Russia on such indicators as "the proportion of households with broadband Internet access" and "the proportion of the population that has ever used the Internet in the total population aged 15–74 years" was immaterial.

The influence of the regional factor on the formation of the analyzed indicators, except the specific gravity of the population using the Internet to receive state and municipal services in electronic form, is weakening. That is, the gap in the possibilities of access to ICT and their use by the population, associated with the regional factor, is being gradually smoothed out in Russia. Despite this, the problem of digital inequality, depending on the type of residence, is quite acute. Table 2 presents the results of variance analysis of the influence of the type of locality on the indicators of accessibility and use of ICT by the population (significance level 5%).

As can be seen from the results in the table, in 2017, the variation in the proportion of households with a PC in the total number of households by 39.2% was caused by differences between urban and rural areas. The territorial factor justified the differences in the proportion of households with broadband access to the Internet by 39.0%, and in the proportion of the population that has ever used the Internet in the total population aged 15–74 years, by 45.9%. Given this, the state policy to bridge

Table 1 The results of the analysis of the impact of regional differences on indicators of access and use of ICT by the population

Indicator	Year	F-statistics	Coefficient of determination (%)	Empirical correlation
The proportion of households with a PC, in the total number of households	2016	4.588	29.4	0.543
	2017	2.369	17.7	0.421
The proportion of households with broadband Internet access, in the total number of households	2016	4.576	29.4	0.542
	2017	1.311	–	–
The proportion of the population that has ever used the Internet, in the total population aged 15–74 years	2016	2.386	17.8	0.422
	2017	1.232	–	–
The proportion of the population using the Internet to order goods, services, in the total population aged 15–74 years	2016	4.435	28.7	0.536
	2017	3.816	25.8	0.508
The proportion of the population using the Internet to receive state and municipal services in electronic form, in the total population aged 15–72 years, receiving state and municipal services	2016	2.024	–	–
	2017	2.274	17.1	0.414
Monthly subscription fee for Internet access per month as a % of average per capita income	2016	4.840	30.6	0.553
	2017	4.343	28.3	0.532
Monthly fee for mobile Internet per month as a % of average per capita income	2016	3.809	25.7	0.507
	2017	2.799	20.3	0.450

Source Calculated by the authors based the Rosstat data [2, 11]

Table 2 The results of the analysis of the impact of the type of terrain on the indicators of accessibility and use of ICT by the population

Indicator	Year	F-statistics	The coefficient of determination (%)	Empirical correlation
The proportion of households with a PC, in the total number of households	2016	126.710	43.4	0.659
	2017	106.589	39.2	0.627
The proportion of households with broadband Internet access, in the total number of households	2016	166.368	50.2	0.709
	2017	105.589	39.0	0.625
The proportion of the population that has ever used the Internet, in the total population aged 15–74 years	2016	192.303	53.8	0.734
	2017	139.883	45.9	0.677
The proportion of the population using the Internet to order goods, services, in the total population aged 15–74 years	2016	59.518	26.5	0.515
	2017	55.338	25.1	0.501
The proportion of the population using the Internet to receive state and municipal services in electronic form, in the total population aged 15–72 years, receiving state and municipal services	2016	81.888	33.2	0.576
	2017	59.292	26.4	0.514

Source Calculated by the authors on the basis of the Rosstat data [2, 11]

the digital divide in the country should be aimed, first of all, at narrowing the digital divide between the rural and urban populations.

In addition to the territorial factor, the formation of indicators of accessibility and usability of ICT by the population is influenced by a broad set of factors, among which there are: the lack of need (“mental access”), lack of skills (“access to skills”), high costs (“material access”), and lack of technical capabilities (“access to use”).

In 2017, among the reasons for not using the Internet in households, the most popular was the lack of need (70.3%). 27% of households without access to the Internet did not use the Internet due to a lack of necessary skills, 18.1% due to the high costs of connecting to the Internet, and 6.2% due to lack of technical capabilities. At the same time, for rural areas, the reason for the lack of technical ability to connect to the Internet is more relevant than for urban areas (in 2017, 12.1% and 3.0%, respectively). Based on the foregoing, the prevailing barrier to the use of the Internet in 2016 and 2017 was "mental access," with "access to skills" and "mental access" also at a reasonably high level, and "access to use" more pronounced in rural areas.

In this regard, it is of considerable interest to identify the relationships between the accessibility and use of ICT in the regions of Russia. Because of the correlation analysis, it was found that the variation in the values of the indicator "Percentage of households with broadband Internet access" in the regions is most affected by the availability of ICTs in cities (Spearman's rank correlation coefficients in 2016 equaled 0.855, and 0.911 in 2017), while the degree of the relationship's tightness is increasing for both urban and rural areas.

A positive trend is observed in the decreased impact of price affordability on the indicators of ICT use by the population and the indicator "proportion of households with broadband Internet access." So, in 2016, there was a significant inverse relationship between price affordability indicators and the proportion of households with broadband Internet access (Spearman's rank coefficients are −0.391 and −0.336, respectively) with the proportion of the population that has ever used the Internet (−0.357 and −0.222), by the specific gravity of the population using the Internet to order goods and services (−0.341 and −0.334), and the specific gravity of the population using the Internet to receive state and municipal services electronically (−0.399—with the monthly fee for mobile Internet per month as a percent of the population's average per capita income). In 2017, a significant correlation of price indicators of ICT availability was observed only in the proportion of the population using the Internet to order goods and services in the total population aged 15–74 years (−0.343 and −0.386).

4 Discussion

Since the use of ICT is becoming a necessary resource for the development of the economy and society, a new component of social stratification appears, requiring the construction of a system of quantitative and qualitative assessment. Moreover, informatization of society and "digital" stratification are causing changes in labor markets, healthcare, education, the behavior of the population and households as consumers, the composition and structure of social capital, etc. Overcoming the digital divide requires, on the one hand, the development of unified state policy, and, on the other, the consideration of regional specifics, which is especially relevant for a country like Russia.

The study shows that territorial differences in the population and households remain a significant factor in inequality, both in terms of access and the use of ICT, which is most evident in the characteristics of the physical and information infrastructure of ICT, as evidenced by the results of the classification of regions and assessing the significance of differences using the variance analysis. Living in urban versus rural areas is a factor of inequality, regardless of the population. In the framework of further research, it seems advisable to study the digital differentiation of urban versus rural populations by settlements with different populations, as well as social groups.

Despite the fact that the relationship between accessibility and use of ICT in the constituent entities of the Russian Federation is significant, the strength of the relationship indicates that factors related to knowledge, skills, and education of the population seem to make a significant contribution to the development of ICT and reduce the digital divide, including inequality in education and the quality of its services.

In the framework of solving research problems, federal districts were identified for which, first of all, it is advisable to develop systemic measures to reduce the digital divide.

Also, the need for more detailed development of digital inequality indicators aimed at monitoring its dynamics in order to solve the problems posed in the program "Information Society (2011–2020)" has been identified [5].

5 Conclusion

Even though an increasing share of the population of Russia recognizes the need for digital competency and opportunities for using ICTs in various fields of activity from everyday life to the use of ICT by enterprises, organizations, and government bodies, inequality in opportunities for digital development remains a significant problem. In Russia, with its significant differentiation of territories according to the level of socio-economic development, digital inequality has been and remains a significant factor hampering economic growth. The results obtained in the study allowed us to conclude that there are several patterns in the "digital" development of the regions. The first of these is the positive trend of reducing the regional gap inaccessibility to the use of ICT by the population and households. Further, it should be noted that the influence of regional differences throughout the studied period remains at a reasonably high level and is important for overcoming digital barriers of development. The study of the strength of the relationship between accessibility and use of ICTs in the constituent entities of Russia, as well as in their urban and rural areas, has shown that the level of skills and knowledge, as well as the material capabilities of the population, are essential factors that must be taken into account when developing programs for reducing digital inequality.

References

1. Bychkova, S.G., Parshintseva, L.S.: Information and communication technologies as the basis for the development of the information society: Russia in the system of international statistical indicators. Stat. Econ. **1**, 32–40 (2019)

2. Federal State Statistics Service: Retrieved from https://www.gks.ru/ (n.d.)
3. G8: Okinawa Charter for the Global Information Society (July 22, 2000). Okinawa, Japan (2000)
4. Gerasimova, E.B.: The analysis of the activity of an economic entity and digital culture. World New Econ **2**, 20–28 (2019)
5. Government of the Russian Federation: State program “Information Society (2011–2020)” (April 15, 2014 No. 313). Moscow, Russia. Retrieved from https://government.ru/rugovclassifier/825/events/ (2014)
6. Hoffman, D., Kalsbeek, W., Novak, T.: Internet and web use in the US. Commun. ACM **39**(12), 36–46 (1996)
7. Katz, J., Aspden, Ph.: Motivations for and barriers to internet usage: results of a national public opinion survey. Internet Res.—Electron. Network. Appl. Policy **7**(3), 170–188 (1997)
8. Keller, J.: Public access issues: an introduction. In: Kahin, B., Keller, J. (eds.) Public Access to the Internet, pp. 34–45. The MIT Press, Cambridge, MA (1995)
9. President of the Russian Federation: Strategy “Information Society Development Strategy in the Russian Federation for 2017–2030” (May 9, 2017 No. 203). Moscow, Russia. Retrieved from https://kremlin.ru/acts/bank/41919/page/1 (2017)
10. Tapscott, D.: The Digital Economy: Promise and Peril in the Age of Networked Intelligence. McGraw-Hill, New York, NY (1994)
11. Unified Interdepartmental Information and Statistical System: Retrieved from https://fedstat.ru/ (n.d.)
12. Van Dijk, J.: The Network Society, Social Aspects of New Media, p. 267. Sage, London, UK (1999)

The Use of Digital Technologies in the Contract System

Tatiana A. Guseva, Andrew L. Pashin, and Elena E. Smetanina

Abstract The purpose of the study is to analyze and determine the ways of using new information technologies in the procurement of goods, works, and services for state (municipal) needs. The principle of a comprehensive study of the object, the principle of conditionality of legal, economic, and technological phenomena, factual reliability, and legality were used as the main methodological principles. The paper proves that the emergence of new organizational and legal mechanisms will contribute to the creation of new models of economic relations, models of entrepreneurship and public administration. Consequently, they will be actively introduced into the system of state (municipal) procurement.

Keywords Goods · Works · Services · State (municipal) needs · Digital rights · Smart contracts

1 Introduction

The problem of finding effective tools for digitalizing economic relations in Russia is caused by the process of implementing the tasks set in a number of regulatory legal acts, where the digital economy is designated an area of priority national projects [9, 10].

In this regard, there is a need to form not only a new sphere of knowledge and a new economic environment but also legal support for the digitalization of all areas of economic activity, including foreign economic activity. This, in turn, implies the formation of a new legal framework regulating the inclusion of digital technologies

T. A. Guseva · A. L. Pashin · E. E. Smetanina (✉)
Orel State University Named After I. S. Turgenev, Orel, Russia
e-mail: eleyna@list.ru

T. A. Guseva
e-mail: guseva2002@rambler.ru

A. L. Pashin
e-mail: andrey-pashin@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_23

in various spheres of public relations, created with the consideration of the need to ensure information security for the state, businesses, and citizens.

Over the past two years, systemic amendments were made to the Federal Law "On the contract system in the field of procurement of goods, works, and services to meet state and municipal needs" (hereinafter the Law on the Contract System) and the relevant acts of the Russian Government Federation [4]. This ensured the formation of a base for the transition from January 1, 2019, to the next stage in the development of the contract system, the main characteristics are:

- the translation of purchases in electronic form, which ensures openness and transparency of procurement;
- ensuring the confidentiality of applications;
- the formation and signing of an electronic contract;
- the provision of security for the performance of an obligation (for example, a bank guarantee) in electronic form;
- the placement of the funds deposited to secure an application for participation in the procurement—not on the settlement account of the electronic site but on the special accounts of the procurement participant with a credit institution;
- the functioning of electronic platforms in accordance with the Law on the Contract System and the establishment of uniform requirements for them;
- the emergence of a catalog of goods, works, and services and the standardization of established requirements;
- the emergence of procurement participants in the Unified Information System in the field of procurement of a single register;
- the automation of procurement control;
- the expansion of the types of goods, works, and services for the purchase of which the contract system is used (procurement of services for the transportation of municipal solid waste, procurement of capital repairs of apartment buildings, among others).

2 Materials and Methods

Over the course of work, the method of comprehensive research of the object was used, which allowed us to consider public procurement from the point of view of spending budget funds; it also helped us understand that it is the digitalization of the procurement process that indicates the new development stage. The application of this method helped determine the prospects for the contract system's further development.

A systematic method was also used, which allowed for a comprehensive study of the system of interaction between law and digital technologies. During the application of this method, both the internal structure and external characteristics, as well as the interactions of the contract system with other objects, are studied.

The method of strategic assessments made it possible to characterize the consequences of legislative changes, taking into account the proposed ways for improving the legal regulation of digital technologies in public procurement.

3 Results

A single procurement information system provides the collection, processing, storage, and provision of information on state and municipal procurements, based on the use of the official website.

The unified information system in the field of procurement in 2018 had 2 million active users; this is 340 TB of information; 400,000 customers; more than 200 external systems integrated with external users; 540,000 potential suppliers with electronic digital signature; ₽21.6 trillion cash volume of contracts; the daily number of requests to the Unified Information System equaled 220 million [8].

At the XV forum exhibition “GOSZAKAZ” held on 04/03/2019, the Treasury of Russia presented an application for work in procurement, the so-called mobile application of the Unified Information System in the field of procurement. This mobile application is developed on the iOS platform. Its goal is to reduce the financial and labor costs of suppliers [14]. With the launch of the program, procurement participants will be able to devote more time to business development.

For the further development of the digitalization of economic turnover, the state (municipal) procurements and the changes in the Civil Code of the Russian Federation (hereinafter the Civil Code of Russia), in accordance with which the concept of “digital rights” is introduced into legal circulation, are important. This is a set of electronic data that certifies the rights to various objects: property, exclusive rights, work results, and the provision of services. The transfer of digital rights from one person to another is ensured by making entries in the appropriate information system.

There were many disputes regarding the inclusion of digital rights in the list of civil rights. For example, the Presidential Council for the Codification and Improvement of Civil Law in its conclusion to the draft law indicated that digital law is a new way of fixing obligations and other rights and not an object of civil rights [2].

Thus, the definition of digital rights appears in the Civil Code of Russia, where digital rights are recognized as obligations and other rights specified in the law. The content and implementation conditions of digital rights are determined in accordance with the rules of an information system that meets the criteria established by law (Article 141.1 of the Civil Code of the Russian Federation). The implementation and disposal of digital rights are possible only in the information system without contacting a third party.

The developers did not include smart contracts as a separate type of contract in the Civil Code of the Russian Federation. According to the Civil Code of Russia, this is just a condition on the automatic execution of any civil contract. For example, a client will instruct the bank to charge a monthly fee for any services in the auto payment mode. Then, the person will receive these services automatically upon the occurrence of the circumstances specified in the agreement; that is, the information system itself will perform the order. In the original version, the developers proposed to include in the law a provision stating that the fact of the execution of a transaction by a computer program cannot be disputed, with the exception of the situation when the parties or third parties influenced the procedure for executing the transaction. In the final version, it was decided to refuse such a norm [13].

Thus, it can be stated that the legal basis for the further digitalization of economic activity, including in the field of public procurement for the needs of government bodies, budgetary, and state institutions, has been summed up.

4 Discussion

How are digital technologies used in public procurement, and how will innovations affect procurement procedures further?

1. The revision of the Law on the Contract System (January 1, 2019) states that, as a general rule, the state customer determines the supplier, contractor, and performers through electronic procedures.

   Using software and hardware complexes on electronic platforms, the customer is sent applications, a protocol for assessing applications. The information about the points received by the participants is sent to the personal accounts of the procurement participants, the procedure of improving the terms of the transaction price is implemented, and the final protocol is drawn up.

   Thus, from January 1, 2019, the conditions for the situations where there is a conspiracy between customers and participants have seriously decreased. The time and financial costs of all procurement participants have decreased. The number of potential suppliers (contractors, performers) has increased due to the possibility of filing applications for participation in the procurement in the form of an electronic document.

   The translation of purchases into electronic format is a worldwide trend that is not only a characteristic of the Russian state procurement system. Thus, the procurement directives of the European Union, as part of the "Europe 2020" strategy, provide the full electronification of procurement by the end of 2018 [1].
2. From November 1, 2018, a specially created Internet resource, the Unified Trade Aggregator (known as Berezka), began to function for individual procurement cases and, from March 1, 2019, for all government customers. This aggregator is located on https://agregatoreat.ru.

   This functionality was created in pursuance of the Order of the Government of the Russian Federation 824-R (2018) for minimizing the corruption component in conducting the purchases of state and municipal customers of up to one hundred thousand rubles [6].

   The Unified Trade Aggregator is an Internet portal, which is in the nature of an online store at which only legal entities and individual entrepreneurs can work. At the same time, only legal entities that have the status of a state or municipal customer, or are equated with them and receive financing from the state or municipal budgets of various forms, can act as buyers [7].

With the advent of "digital law," it is possible to change the technology of the Berezka Trading Aggregator: based on the specified requirements, the system can select the product, work, or service that meets the requirements and enter into a contract with certain conditions automatically. Using this technology, a smart contract could be charged penalties and fines for violation of the terms of the contract in automatic mode.

According to experts, the use of smart contract technology can cause serious reform of the traditional institutions of classical contract law [12].

3. According to the amendments to the Law on the Contract System, the customer will be able to return the contract security to the contractor in proportion to the completed procurement stages. This rule will work if the supplier performs the work without fines and penalties [5].

   In particular, after the supplier (contractor, performer) fulfilled the obligations or their part, the customer would send information about this for inclusion in the relevant register of contracts. Then the size of the contract execution security is reduced in proportion to the cost of the obligations fulfilled.

4. The creation of an information environment in the field of state and municipal procurement is the beginning of the formation of a full-fledged intellectual information system. This does not exclude certain risks, the inefficiency of such purchases, or the inability of software environments to take into account all sorts of factors. Thus, there was more than one case of bid breakdown when no one went to the auction due to the use of reference prices for medicines, which were significantly different from market prices. The experts from the Russian Popular Front, "For Fair Purchasing," analyzed information on government procurement of medicines in 2017–2018 based on the provided data by the Federal Treasury, and found that in a number of regions, every fourth procurement procedure was declared failed due to a lack of applications. In the whole country, the number of failed auctions for the year increased by 3%, but in some entities, the growth was significant: in the Republic of Mari El, by 215%; in the Chelyabinsk region, by 115% [11].

   The experts of the public association are sure that the key is in the new procedure for determining the initial maximum price of the contract. In particular, the lowest possible price is taken, which does not always reflect the real purchase price. Reference prices are calculated automatically by a unified state information system in the field of health care. Information on reference prices is provided in a unified information system in the field of procurement.

   The Federal Antimonopoly Service (hereinafter referred to as the FAS Russia) and the state corporation Rostec are developing an electronic resource that, based on available information (including similar purchases made earlier), will help automatically generate the subject of the purchase and the initial price before the announcement of the purchase. It will help prevent errors during the procurement procedure [3].

5. Further improving the contract system is associated with simplifying the procurement procedure when procurement from the catalog of goods, works, and services becomes the main procurement procedure. Thus, to conclude a state contract, information from the catalog of goods, works, and services and a standard contract from the Unified Information System in the field of procurement will be necessary. In competitive procurement, the transition from complex procedures to the catalog will prevent describing the procurement object for a specific supplier.

   A catalog of goods, works, and services is a systematic list of goods, works, and services purchased for meeting state and municipal needs, formed on the basis of the Russian classifier of products by type of economic activity.
6. Electronic procurement has significantly improved the position of procurement participants. Thus, if earlier, for participation in electronic procedures, the participant had to potentially get accreditation on all electronic platforms and pay a fee for this, then from January 1, 2019, to participate in the auction, registration in the Unified Information System in the field of procurement is required; after that, the electronic trading operator sites carry out the accreditation of a participant on electronic platforms. Registration in the Unified Procurement Information System is free of charge.

   Data on bidders (legal entities, individual entrepreneurs) is updated daily since the Unified Procurement Information System is integrated with the Unified State Register of Legal Entities and the Unified State Register of Individual Entrepreneurs maintained by the Federal Tax Service. This excludes situations when a bidder enters the auction with an expired power of attorney for a representative or with the address different from that indicated in the constituent documents, when the organization is represented by a director whose authority has long expired, and so on.

   The registration of a participant in the Unified Information System in the field of procurement is terminated either upon application or automatically (upon expiration of the registration period of three years, as well as in the event of receipt of information about the termination of the activity of the procurement participant as a legal entity or individual entrepreneur).

5 Conclusion

Procurement for state (municipal) needs, as they are organized at the present time, is already the digitalization of economic turnover. In particular, the characteristics of the procurement system confirming this conclusion are as follows: storing the results in a distributed network that ensures the integrity of the information flow between the participants, its immutability; generalization and analysis of big data and the possibility of obtaining conclusions for the implementation of strategic goals or objectives;

cataloging purchases as establishing standardized requirements; electronic search for procurement information, search for best offers and so on.

Thus, public (municipal) procurements are part of the information and telecommunication infrastructure of the public sector economy. Therefore, they are dependent on information technology and development factors of software and hardware in general. The very existence of a contract system is a synthesis of economics, law, and the use of digital technology.

References

1. Bizhoev, B.M.: The fundamentals of an intellectual contract system in the field of public procurement. J. Econ. Regul. **9**, 110–122 (2018)
2. Council Under the President of the Russian Federation on the Codification and Improvement of Civil Law: Overview of the activities of the Presidential Council on the codification and improvement of civil law for January 2019. Retrieved from https://privlaw.ru/sovet-po-kodifikacii/2019-1/obzor2019-1/ (2019)
3. Federal Antimonopoly Service of Russia: FAS and ROSTECH are working on an information system that prevents errors in public procurement. Retrieved from https://fas.gov.ru/publications/14036 (2017)
4. Federal Assembly of the Russian Federation: Federal law "on the contract system in the sphere of procurement of goods, works, and services for ensuring state and municipal needs" (April 5, 2013 No 44-FZ). Moscow, Russia. Retrieved from https://www.consultant.ru/document/cons_doc_LAW_144624/ (2013)
5. Federal Assembly of the Russian Federation: Federal Law "on amending the federal law "on the contract system in the sphere of procurement of goods, works, and services for ensuring state and municipal needs"" (December 31, 2018, No 502-FZ). Moscow, Russia. Retrieved from https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=LAW&n=314642&fld=134&dst=1000000001,0&rnd=0.4470274542384618#008185914164438612 (2018)
6. Government of the Russian Federation: Decree "On the creation of a single trade aggregator, with the use of which customers have the right to make purchases to ensure state and municipal needs" (April 28, No 824-r). Moscow, Russia. Retrieved from https://www.garant.ru/products/ipo/prime/doc/71835580/ (2018)
7. JSC "RT-Design Technologies": The rules for the operation of a single trade aggregator. Retrieved from https://agregatoreat.ru/materials/regulations (2019)
8. Katamadze, A.T.: The main directions of digitalization of public procurement. Impact on public procurement economics. Retrieved from https://goszakaz.ranepa.ru/images/pdf/Katamadze.pdf (2019)
9. President of the Russian Federation: Decree "on the strategy for the development of the information society in the Russian Federation for 2017–2030" (May 9, 2017 No. 203). Moscow, Russia. Retrieved from https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=LAW&n=216363&fld=134&dst=1000000001,0&rnd=0.291499722869349#033247417634395315 (2017)
10. President of the Russian Federation: Decree "on national goals and strategic objectives of the development of the Russian Federation for the period until 2024" (May 7, 2018, No. 204). Moscow, Russia. Retrieved from https://www.consultant.ru/document/cons_doc_LAW_297432/ (2018)
11. Russian Popular Front "For Fair Purchasing": RPF asks FAS and the Ministry of Health to take urgent measures to establish procedures for the procurement of vital medicines. Retrieved from https://onf.ru/2019/02/04/onf-prosit-fas-i-minzdrav-rf-prinyat-srochnye-mery-po-nalazhivaniyu-procedur-zakupki/ (2019)

12. Saveliev, A.I.: Contract Law 2.0: smart contracts as the beginning of the end of classic contract law. Civil Law Bull., 32–59
13. Shestakova, M.: Digital rights as a new type of civil rights. What else has changed in the Civil Code of the Russian Federation? Economics and life. Retrieved from https://www.eg-online.ru/article/396138/ (2019)
14. Sidaev, D.: The Treasury has developed an EIS mobile application. Retrieved from https://goscontract.info/podgotovka-k-tenderu/kaznacheystvo-razrabotalo-mobilnoe-prilozhenie-yeis?utm_campaign=22042019&utm_source=sendpulse&utm_medium=email (2019)

Consumer Cooperation in Russia in the Digital Economy

Valentina M. Kruchinina and Svetlana M. Ryzhkova

Abstract Consumer cooperation continues to be an important part of the distribution infrastructure. Recently, the state has adopted programs to develop the digital economy. The aim of the paper is to study the influence of digital technologies on the further development of the organizations of the Central Union for the quality of public services. The authors present an analysis of the activities of consumer cooperation, consider the possibilities of digital technologies that can have a positive impact on the development of the Central Union system and increase the level of well-being of the rural population. The authors used abstract logical, monographic, economic, and statistical methods and came to the following conclusions: digital technologies facilitate access to various kinds of information and can assist in the development of consumer cooperation. Digital technologies are aimed at improving the daily life of a person. This is their similarity with the goals of the activities of consumer cooperation organizations. There is no clear state policy for the development of the digital economy and individual industries in Russia, therefore, inter-industry cooperation, state-cooperative, and cooperative-private partnerships are important.

Keywords Consumer cooperation · Digital economy · Sustainable development · Standard of living · State-cooperative partnership

1 Introduction

Consumer cooperation in the system of the Central Union was an important part of the country's economy, but with the development of market relations, it began to have competitors, for example, retail chains, agricultural consumer cooperation, etc. At the same time, there are areas where none of the market entities can replace it

V. M. Kruchinina (✉) · S. M. Ryzhkova
Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: vmk.market@vniiesh.ru

S. M. Ryzhkova
e-mail: smr.market@vniiesh.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_24

(the most remote corners of Russia and small settlements). In recent years, programs for the development of the digital economy have been discussed and adopted in the country, which may also influence the further development of cooperation.

2 Materials and Methods

The materials of the study are the papers published in printed periodicals and received through the Internet. In Russia, there are no official statistics for various types of cooperatives. The only system that has statistics on its organizations is the consumer cooperation of the Central Union. Rosstat also takes into account data on small business forms and households. These market entities act as an environment for the formation and development of various cooperative entities, so the authors base the research on the data of these structures.

The authors used the following methods: abstract logic in the study of legislation on the digital economy and its impact on consumer cooperation; analysis, comparison, induction, and deduction when considering the activities of consumer cooperation; monographic methods in developing recommendations for further development of consumer cooperation.

3 Results

Since its inception, consumer attention has been focused on foreign scholars and practitioners, founders, and innovators who have made invaluable contributions to the formation of cooperative thought, namely R. Owen, Ch. Fourier, W. King, C. Howard, G. Kaufman, F. W. Raiffeisen, F. H. Schulze-Delitzsch, Ch. Gide, M. Mariani, etc. In Russia, before the revolution, K. A. Pajitnov, N. Ballin, M. I. Tugan-Baranovsky, V. F. Totomyantz, A. V. Chayanov, K. V. Emelyanov, etc. were engaged in cooperative problems [12].

In 1917, one of the theorists of cooperation, A. N. Antsyferov, wrote: "Together with the fall of the old regime, Russian cooperation opened up the possibility of fulfilling its long-held dream, creating a unified and solid legal foundation for itself and, based on this foundation, to develop freely" [1]. The same probability arose in cooperation with the new reality—the transition to a market economy. In the USSR, as in tsarist Russia, the authorities were afraid of the "development of free cooperation" and, therefore, its types were limited. Thus, throughout Soviet history, the main type of cooperation for a long time was the consumer cooperation of the Central Union system (CS). However, in market conditions, "every cooperative partnership can arise freely" in accordance with local needs and requirements [1]. Therefore, since the 1990s, various types of cooperatives began to appear, including production, consumer, housing, agricultural consumer and agricultural production, credit, horticultural, etc. In world practice, energy, export, organic, marketing, service, medical cooperatives, social services, etc., which have not yet received proper development in Russia, are in demand.

In the absence of official statistics, it is difficult to determine the size of each type of cooperative and its share in the country's GDP. It is possible to rely on data on small forms of managing and farms of the population considered by Rosstat. The only system that has statistics on its organizations is the Central Union. In modern Russia, consumer cooperation has surrendered its position in providing comprehensive services to the rural population. It has been significantly replaced by private stores, and in recent years, network retail has come to regional centers. Nevertheless, despite the difficulties, the Central Union is an economic system that can transform and develop effectively in the future [6].

As of 01/01/2018, the system of consumer cooperation was supported by 1832 thousand shareholders. Over the past five years, the number of shareholders has decreased by 33.7%, while the number of consumer companies has decreased by 14.5% over the same period. The structure of the Central Union includes 2297 consumer societies, of which, structurally, 69.5% are consumer societies, 25.4% are district consumer societies, and 4.6% are urban (Table 1).

The largest numbers of consumer societies fall in the Volga and Siberian Federal Districts, whose shares in the total amount are 28.6% and 20.4%, respectively (Fig. 1).

The total volume of activities in 2017 amounted to ₽217.2 million, 3.2% less than in 2016 (₽224.3 million). In 2017, the total profit in the amount of ₽2819.6 million was received, 8.5% lower than the 2016 profit. In the USSR, consumer cooperation accounted for a significant part of the country's GDP, but in 2010 its share of GDP amounted to 0.5% and in 2017 only 0.25% (Table 2).

Table 1 The number of shareholders and the organizational structure of consumer cooperation in Russia

Indicators	Years					2017–2013, %
	2010	2011	2012	2013	2017	
The number of shareholders, thousand people	3718	3587	2880	2723	1832	67.3
Consumer societies, total	2919	2721	2762	2686	2297	85.5
Including						
Consumer societies	1978	1882	1895	1849	1597	86.4
Urban consumer societies	132	137	139	128	106	82.8
School and student consumer societies	11	11	11	11	10	90.9
District consumer societies	798	691	717	698	584	83.7
Regional and county consumer societies	155	151	130	128	111	86.7

Source Compiled by the authors [2]

Fig. 1 Distribution structure of consumer companies by Federal Districts in 2017, % [2]. *Source* Compiled by the authors

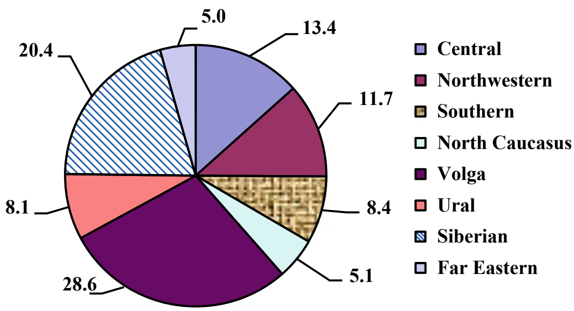

Table 2 The total turnover of the Central Union in Russia's GDP

Indicator	Years					2017–2016, %
	2013	2014	2015	2016	2017	
Total activity, ₽ billion	258.7	243.4	231.7	224.3	217.2	96.8
Total profit, ₽ million	3527.2	2796.1	3801.4	3082.4	2819.6	91.5
Gross domestic product, ₽ trillion	71.0	77.9	80.8	83.9	88.2	105.1
The share of total Central Union turnover in the country's GDP, %	0.4	0.3	0.3	0.3	0.25	−0.05 points

Source Compiled by the authors [2]

Consumer cooperative organizations, as a rule, work in rural areas and serve the poorest part of the country's population. Thus, in 2018 the wages of those employed in crop production, animal husbandry, hunting, and the provision of services in these areas amounted to ₽25,431, 3.3 times lower than in mining sectors, 1.6 times lower than in the manufacturing industry, 37.7% lower than the wholesale and retail trade, 3.6 times lower than in the financial and insurance sectors, and also 1.7 times less than the average Russian (Federal State Statistic Service).

The decline in the quality of life of rural residents (lack of cultural houses, libraries, the closure of medical facilities and schools, the low level of quality of the road surface or its absence, etc.) leads to a decrease in the interest of villagers and youth in living in rural areas and justifies the desire to move to urban settlements. In addition, the inaccessibility of permanent work in their settlements forces some residents to leave to work in the cities. Compared with 1990, in 2017, the rural population decreased by 1156.9 thousand people and makes up 26% of the total population of Russia (for comparison: in 1914, in modern borders, 83% of the population lived in rural areas). In 2017, changes in abundance for all parameters showed negative values. For example, the total growth of the population decreased by 218.5 thousand people, natural growth—by 95.1 thousand people, migration growth-by 46.5 thousand people, and due to the change in the category of settlements—by 76.9 thousand people in comparison with 2016 (Federal State Statistic Service).

The digital economy can become an assistant in solving accumulated problems both in rural areas and in consumer cooperation. The digital economy can become an assistant in solving accumulated problems both in rural areas and in consumer cooperation. Thus, in rural areas, the proportion of households using individual services of digital, cable, satellite television, and mobile communications is higher. However, Internet access is significantly lower compared to households in urban areas. For example, 3.8% of rural households can access the Internet via wireless networks in public places, compared to 13.5% of urban households. In 2017, the level of digitalization of the local telephone network in urban areas was 93.5%, and in rural areas, 83.1% (Table 3).

In this case, the use of digital technologies helps rural residents meet previously inaccessible needs and demands. For example, the benefits for consumers are expressed in access to a wider range of goods and services at competitive prices, and for entrepreneurs in new business opportunities and job creation, sometimes remote.

In general, in Russia in 2016, the share of residents using broadband Internet access equaled 18.8%. There were almost 160 mobile phones per 100 people, and 71.3 out of 100 people used mobile Internet access. The average speed of the Internet connection has increased to 12.2 Mbit/s, which is equal to the level of such developed countries as Italy, France, and Greece [5].

The creation of conditions for a decent life and the harmonious development of the rural population is the prerogative of the state. In recent years, several policy documents have been adopted. These state that the accelerated introduction of digital technologies into the economy and social sphere is aimed at improving the living standards of citizens, creating comfortable conditions for their living, and creating conditions and opportunities for self-realization [8]. The changes should also affect the basic sectors of the economy, including agriculture.

The state intends to solve several problems in the field of medium and small businesses. It plans to improve the conditions for doing business, including simplifying tax reporting for entrepreneurs using cash registers, create digital platforms aimed at supporting the production and marketing activities of small and medium-sized enterprises, including entrepreneurs, improve the procurement systems carried out by the largest customers from small and medium-sized enterprises, including private entrepreneurs, simplify access to concessional financing with an annual increase in the volume of concessional loans granted to small and medium-sized enterprises, including entrepreneurs, modernize the support system for exporters who are small and medium-sized enterprises, including entrepreneurs, and create a system of support for farmers and the development of rural cooperation [8].

The program "Digital Economy of the Russian Federation," due to lack of funding, was canceled on 02/19/2019, but was in demand and identified three levels of the digital economy that affect the lives of citizens and society:

Table 3 The households with the access to television, Internet, and telephone services and their costs

Indicators	Households, 2017 r		
	Total	Including	
		City	Village
All households, of which in %	100	100	100
Households using television reception services, including those using:	81.8	86.1	68.1
Services of the collective (communal metering) antenna	20.9	25.9	4.8
Individual services of digital, cable, satellite TV	60.9	60.2	63.3
Households using communication devices, including those using:	100	100	100
Landline (home) phone only	0.5	0.5	0.5
Mobile phone only	55.1	52.3	64.2
Landline and cell phone	44.3	47.2	35.3
Households using Internet access, including those using:	80.1	82.6	72.1
Internet only through wired and wireless devices installed at home	52.0	56.4	38.0
Internet through wireless devices (WiFi, etc.)	30.0	33.0	20.7
Internet through a cellular network	41.2	42.9	35.7
Internet via wireless networks (WiFi, etc.) in public places	11.2	13.5	3.8
Internet through the network at the place of work (study)	14.1	16.2	7.3
The expenses for payment of television, Internet, and telephone services on average per household that used the corresponding services, per month, ₽—which total is the cost of payment of:	1303.8	1373.4	1081.7
The services of the collective (communal metering) antenna	31.4	39.6	5.2
Individual services of digital, cable, satellite television	72.0	74.5	64.0
Landline (home) phone	136.7	150.0	94.2
Cell phone	366.2	367.5	362.0
Wired and wireless home internet	266.3	271.5	249.8
Mobile internet	42.5	35.1	65.9

Source Federal State Statistic Service

- markets and sectors of the economy (areas of activity) where specific entities (suppliers and consumers of goods, works, and services) interact;
- the platforms and technologies where competencies are formed for the development of markets and sectors of the economy (fields of activity);
- the environment that creates the conditions for the development of platforms and technologies and the effective interaction of market entities and economic sectors (fields of activity) and covers regulation, information infrastructure, human resources, and information security [5].

Digital technologies are aimed at improving the daily life of a person. This is what they have in common with the activities of consumer cooperation organizations. A prerequisite for the effective development of markets and industries in the digital economy is the advance formation of technologies, platforms, and institutional and infrastructural environments, which in close cooperation can give a synergistic effect.

The Internet can be used to advertise the products; maintaining a site is much cheaper than advertising on paper or banners. Consumer cooperation organizations in 2018 produced industrial products worth ₽21,254 million. The assortment consists of the following: bread and bakery products, soft drinks, canned goods, confectionery and sausages, and semi-finished meat products. The products are produced from local raw materials in small batches, and such products are more trusted by customers than industrially manufactured products of foreign production with a large number of preservatives. Organic products are in demand among young people. They are readily purchased for the nutrition of children, in the female audience, as well as among people who monitor their health. The Internet is also driving the promotion of green products. It is also advisable to use its capabilities for the purposes of an advertising campaign for products of its own production to cover the market in neighboring areas.

The reduction of social facilities in villages is one of the reasons for the reluctance to live in rural areas. Often, local authorities do not have enough funds to build small objects, such as playgrounds or sports grounds. Using the opportunities of state-cooperative partnerships, as well as attracting modern funds, such as crowdfunding, can make it possible, for example, to create a children's corner in a cooperative store. Crowdfunding will allow people to collect money from interested parties, who may not be members of the cooperative or even live in another place.

Cooperators and farmers lack the knowledge to create a cooperative and organize their work. There is a need for legal advice. In addition, cooperative and peasant farms cannot always afford to hire agronomists, livestock specialists, veterinarians, and other specialists. Therefore, remote consultations via the Internet can solve some of the problems. The same applies to the hiring of accountants. The accountant can be an overwhelming burden to both the farmer and the cooperative. A non-staff accountant at a remote location, at an hourly rate, can be an option for peasant farms and entrepreneurs [7].

Unfortunately, in Russia, there is no clear state policy for the development of the digital economy. Also, it is difficult for industries to promote digital technologies, which require significant material costs at the stage of development, launch, and

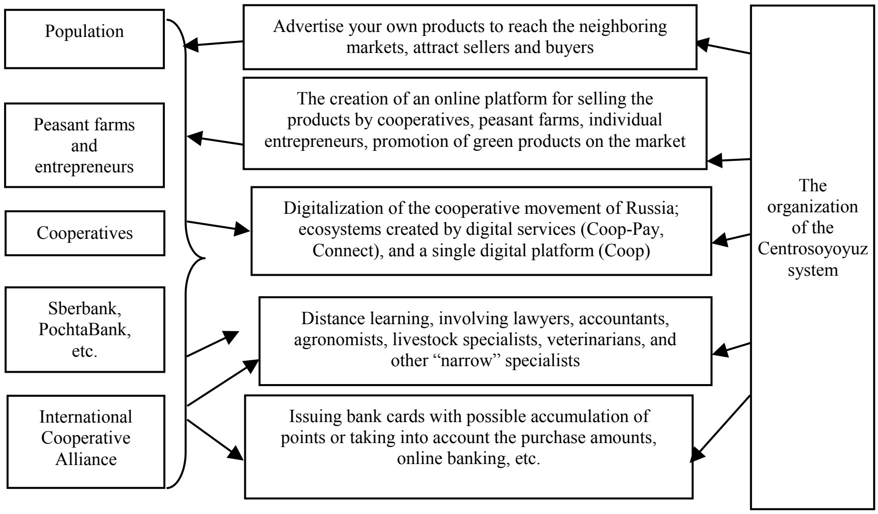

Fig. 2 The model for the use of digital technologies by the Central Union. *Source* Compiled by the authors

maintenance. Therefore, for the effective development of the economy, intersectoral cooperation is important. The Central Union has to independently seek partners and sources of financing for the creation of digital platforms that promote the development of industries, expand the family of shareholders, attract buyers and suppliers of raw materials and products (Fig. 2).

Over the past two years, the Central Union has been engaged in digitalization of the cooperative movement in Russia, creating an ecosystem of digital services Coop-Pay, Connect, and a single digital platform Coop; developing ideas for cooperation, cooperative education, using its website and the sites of regional and regional consumer unions to promote the cooperative model in order to the implementation of the global sustainable development agenda, the creation of a federal network of wholesale distribution centers of the Central Union, the Auto Shop program, and the construction of a cooperative trading network in uniform standards (Central Union).

4 Discussion

Consumer cooperation is a complex of various industries: wholesale and retail trade, public catering, own processing industry, procurement, transport, provision of household services, etc. [9]. Historically, consumer cooperation is designed to ensure the growth of the welfare of rural residents. For modern Russia, the cooperative type of business can be used as a solution that promotes income distribution, reduces poverty and vulnerability, and improves the quality of life and social security of rural residents. In order to improve competitiveness, it is necessary to modernize and introduce new technologies and smart solutions while maintaining a focus on profitability [11]. Innovation is a factor in the country's economic growth, so the state should take an active part in the development of the digital economy [12].

The confirmation of the need for progress can be found in the heritage of Russian cooperators, one of which I. A. Shapiro, in the *Guide to All Types of Cooperation*, wrote: "The general tendency of modern economic life is the increasing abandonment of the outdated system of economy and the replacement of the last new, improved system. … The success of cooperation in any country depends on the cultural and moral level of its population. But, obviously, the general course of humanity is a progressive movement. That, on the one hand, the amount of human knowledge is increasing every day, and on the other, enlightenment is spreading ever wider and wider among the masses. Thus, the continuity of progress is the key to future achievements of cooperation" [10].

5 Conclusion

Despite economic and financial difficulties, consumer cooperation organizations constitute a large socio-economic system operating in rural areas and are often the only city-forming entities. The weak point in the use of the Internet in the activities of consumer cooperation remains its limited capabilities in Russia. After 2000, the Central Union by inertia carried out a social order without state funding, but creating the conditions for a decent life and harmonious development of the rural population is the task of the state. Therefore, one of the directions of forward movement remains cooperative-private and state-cooperative partnerships, as well as the use of the latest achievements of the digital economy, which can help the Central Union in its development for the benefit of rural residents.

Acknowledgements The authors would like to express their gratitude towards the employees of the reading room, the archive of the library of the Russian University of Cooperation for the opportunity to use the literature on cooperation.

References

1. Antsyferov, A.N.: The new cooperative law and the immediate tasks of Russian cooperation. Russia, Moscow (1917)
2. Central Union: Key indicators of socio-economic activity of consumer cooperation in the Russian Federation. Retrieved from https://www.rus.coop/about/figures (2018)
3. Central Union: Official website. Retrieved from https://rus.coop/ru (n.d.)
4. Federal State Statistics Service: Official website. Retrieved from https://www.gks.ru (n.d.)
5. Government of the Russian Federation. Program "Digital Economy of the Russian Federation" (No. 1632-r). Moscow, Russia. Retrieved from https://www.consultant.ru/document/cons_doc_LAW_221756/ (2017)

6. Kruchinina, V.M.: Trends in development of centrosojuz system consumer cooperation in the crisis in the economy. Herald of the Belgorod University of Cooperation, Econ. Law **1**(57), 262–272 (2016)
7. Kruchinina, V.M.: Cooperatives as a tool of development organic agriculture in Russia. Proceedings of VSUET **80**(1), 251–260 (2018)
8. President of the Russian Federation: Decree "On national goals and strategic objectives of the development of the Russian Federation for the period until 2024" (№204). Moscow, Russia. Retrieved from https://docs.cntd.ru/document/557309575 (2018)
9. Ryzhkova, S.M.: On the question of the formation of wild plants clusters on the regional level. Herald of the Belgorod University of Cooperation. Econ. Law **4**(65), 216–231 (2017)
10. Shapiro, I.A.: A Guide to All Sectors of Cooperation: Theory, Practice and History of Consumer, Credit, Production, and Agricultural Cooperatives. Prometheus, St. Petersburg, Russia (1914)
11. Sharkova, A.V., Kilyachkov, N.A., Belobragin, V.V.: The concept of effective entrepreneurship in the field of new solutions, projects, and hypotheses (641). Publishing and Trading Corporation "Dashkov & Co.", Moscow, Russia (2019)
12. Sharkova, A.V., Prudnikova, A.A., Kolesnik, G.V.: Enterprise development: concepts, digital technologies, effective system (605). Publishing and Trading Corporation "Dashkov & Co.", Moscow, Russia (2019)

The Nature of the Social Gift in the Age of Digitalization

Mikhail Y. Zakharov, Irina E. Starovoytova, and Anastasiya V. Shishkova

Abstract The purpose of the study is to analyze various approaches to understanding the nature of gift giving, revealing the characteristics of a social gift as an important resource for establishing and strengthening business and informal relations between partners for optimizing corporate efficiency. The authors of the paper relied on the contemporary foreign and domestic scientific literature on the researched topic. The paper shows that a social gift is a non-verbal means of communication, a carrier of encoded information about the giver, the recipient and the gift situation itself, aimed at establishing, maintaining, and strengthening long-term social ties. The authors note the significant differences between a social gift in its goals and objectives and a bureaucratic gift considered as a social and bureaucratic bribe. The authors of the paper demonstrate that along with the positive aspects of social donation, negative aspects are inevitable, including an increase in the moment of uncertainty, non-guaranteed positivity of the consequences of the gift. The novelty of the study lies in the fact that the main trends in the modernization of social gift in the digital age are identified. First, a social gift is based on new norms, standards, and values. Second, the non-utilitarian significance, informal character, and emotional coloring of a social gift in the digital age is growing. Third, the exchange of social gifts in a networked society is nonequivalent. Fourth, there are new forms of social gifts (virtual gifts, digital gifts). Fifth, specialists in the field of human resources management are faced with new problems: difficulties in algorithmizing and digitalizing a gift, the risks of being too open in connection with the distribution of gifts on the Internet, and the risk of losing the national-cultural component of a social gift. The paper may be interesting and useful to specialists in the field of personnel management, everyone interested in the transformations taking place in the digital society.

M. Y. Zakharov · I. E. Starovoytova (✉) · A. V. Shishkova
State University of Management, Moscow, Russia
e-mail: iestar1@mail.ru

M. Y. Zakharov
e-mail: m.u.zaharov@gmail.com

A. V. Shishkova
e-mail: avs.guu@gmail.com

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_25

Keywords Social gift · Social bribe · Digital gift · Digitalization · Social communication

1 Introduction

Through socializing, a person masters social norms and standards, which, on the one hand, level his behavior and train of thought, and, on the other hand, allow him to communicate with other individuals and social groups.

Presenting gifts, or giving (дарение), is one of the events of socialization. Giving is a procedurally, ritually designed holiday event that brightens one's day.

The main subject of giving is a gift. In the explanatory dictionary of Dahl, the word "present" is defined as "*give as a gift*" [6]. However, the gift is not free. Analysis of scientific literature shows that the essence of a gift is not in material benefits, but in relationships that are formed in the process of giving, and subsequently are supported and deepened by the tradition of the gift.

The corporate effectiveness of an organization largely depends on the relationship that the organization builds with partners and customers. The exchange of gifts aimed at establishing relationships is one of the business rituals that is undergoing significant qualitative changes in the digital age.

2 Materials and Methods

2.1 The Concept of the Social Gift

There are several scientific approaches to understanding the essence of the gift. The French ethnographer and sociologist Moss [15], in his "*Essay on the Gift*," talking about the conditions for maintaining equilibrium in a social group and society as a whole, emphasizes the importance of material exchange, due to which interpersonal relationships are built between groups of people. The "give and receive" relationship balances any social group, the gift is always useful for the person to whom it is intended, but the motive of the giver is always self-serving. Therefore, the essence of any gift is the sum of self-interest and utility for others.

The French sociologist Levy-Strauss [14], explains the phenomenon of giving not by the self-interest of the giver, but by the moral condition of the act of giving. According to the scholar, the system of non-mechanical moral acts strengthens interpersonal relationships within a social group, as well as the relationship between the individual and the group itself. This is possible since there is a minimum amount of rationality in the act of giving.

In a 2006 study, the author proposes a third approach based on the communal-commitment paradigm. Under this approach, givers live in a society consisting of a network of social systems. The exchange of gifts is cyclical, and the act of giving is not only visible directly to the giver and recipient. Gifts are exchanged between members of the community; social relations between them play a decisive role in the choice of a gift [11].

In the structure of the act of giving, it is necessary to single out, firstly, the subject of giving. This item can be animate and inanimate, a thing that has various forms, an event, a ceremony, and even a perfection (или даже индивидуальным образом). A gift is always a social construct that initially does not have the status of a gift, but acquires it in the process of the act of giving itself. Secondly, the act of giving is always accompanied by a ritual situation. This is a complex set of ritualized actions, relationships, and connections that are either first formed, maintained, or restored. In the ritual situation, the meaning of the gift is constructed, and a space is formed that unites all the sociocultural fields of the participants in the act of gifting. The solution to the problem of forming a unifying space is always meaningful, even if a gift is given spontaneously.

The answer to a material gift can be an intangible thing–an increase in the self-esteem of the giver or a certain feeling of gratitude, dependence on the part of the receiver, or another form (making amends, showing affection, etc.). However, one condition that everyone planning to get a return gift is trying to fulfill is to take into account national characteristics, status, personal needs, interests, desires, and passions of the gifted person. Along with this, there is a whole range of formal rules that must be implemented to obtain a gift status that matches the specific situation. This is not an easy task since it is necessary to turn a certain resource (for example, money, a personal thing) into a gift filled with a certain meaning, and so that the result of this sacralization is a value that is equally perceived by all parties to the act of donation.

Social giving is the act of the donor transferring a certain social gift to the circle of recipients with an emphasized lack of personal benefit, but the presence of interest. The main task is the spiritual satisfaction of the donor in order to form a stable subsequent interaction to solve common problems. Social giving has a number of features.

1. With social donation, the donor receives a certain emotional response in return.
2. The giver and the receiver (individual or collective) may belong to different social groups, with a set of their specific needs and interests. However, the donor, realizing this, consciously chooses his social role and acts in transpersonal interests.
3. The giver and the receiver share a common system of values, and their implementation will be facilitated by the gift.
4. The value of a social gift is difficult to determine. The cost of an ordinary gift is determined by the monetary equivalent: the higher the price, the more expensive the gift. Therefore, unnecessary and complex material obligations are imposed on the giver in return. In the case of a social gift, the true value is also determined by the residual positive or negative emotional impressions of the person presented.

5. The need for a gift is not formed by external circumstances, but by internal motivations or motives of the giver himself. A person voluntarily assumes the fulfillment of a socio-cultural role in transferring his resources.
6. In the social gift ritual, the emphasis is not on the gift or the personality of the donor, but on the transfer process and the relationships formed by this process.
7. Giving a social gift has a conscious basis and is prolonged.
8. Conscious attitudes about the choice of gifts of this kind have their own social limitations, both personal and national.

2.2 Social Gifts and Bribes

Compared to a social gift, a completely different task is performed by a social bribe, a bureaucratic gift, and a bureaucratic bribe.

A social gift is the exchange of private resources between individuals or members of a social group whose main purpose is to create, strengthen, and maintain social ties. The organizational affiliation of the participants does not matter. The exchange of gifts is regulated by informal norms, but the acts of giving themselves are quite transparent.

A social bribe also has social functions, but the resources of the organization are used in the act of exchange, and the act of exchange is not transparent. Thus, the community and individuals benefit from the strengthening of social ties, but the organization loses resources.

The bureaucratic gift is a transparent and formally regulated form of gift that simulates social gifting for strengthening relations between the participants of the bureaucratic relations, including between individual organizations. Usually, it is distinguished by a lesser degree of reciprocity, as recipients of gifts see behind them a calculation, not a sincere help.

The main function of a bureaucratic bribe is also the survival of the organization, although individuals may also be beneficiaries. A formal violation of the rules in the process of giving a bribe is regulated by informal norms and is supported by the organization's corruption culture. In the case of a bureaucratic bribe, the loser is usually society [8].

3 Results

3.1 Social Gifting as Information

The non-utilitarian value of a gift has increased in the information society. A gift acts as a carrier of social information (this is information that directly relates to the relations of people, their interactions, their needs, interests, etc.) [1].

A gift, acting as a carrier of social information, appears before the recipient in the form of a signal, sign, or socio-cultural symbol.

The gift is not only a carrier of cultural symbols. It is also used by people as a means of communication. A social gift is an act of communication, not using lexical or verbal means, but things and objects [4].

Presenting a gift, people tend to convey information about the nature of the relationship or do it involuntarily. In order to do this, they use a certain set of characters rooted in a given culture. In addition, the gift can act as a symbol depending on the communication situation. A gift can be interpreted as a hidden text or encoded message [3]. This is a text that we read based on stereotypes and traditions rooted in culture, the characteristics of the social group to which we belong, personal experience, etc.

3.2 Social Gifting as Communication

Giving is an act of communication. In the process of communication, there occurs messaging, i.e., information is transferred from one participant to another. Information is encoded using a specific character system, transmitted and then decoded, or interpreted by the message recipient. A gift transfers to the receiver only the information that he is ready to read, and, in return, agree to establish the desired relationship between individuals or social groups.

A gift, performing the functions of social communication, turns into a text, a sign that carries information about the giver, recipient, and the gift situation.

Information about the giver takes the form of self-presentation and impression management. The behavior and emotional state of the giver are programmed in a certain way; the gift itself forms the status-role positions of the participants.

4 Discussion

On the one hand, the positive value of the gift is obvious. “A correctly selected and successfully handed, in all senses, the gift can have an undeniably positive impact on the formation of a single semantic field of the giver and the recipient in a common information and symbolic space for them” [9].

The gift, acting as a carrier of social information, promotes consolidation, giving the event a positive emotional tone. The gift is a symbol of the present or future good relationship between the giver and the receiver. The symbol, transmitted via a gift, signals an event that should be remembered or not forgotten, which is the key to long-term, future communications.

On the other hand, a social gift in today’s dynamic world carries a negative connotation.

Information acquired in the process of donation complicates a person's life and increases the moment of uncertainty contained in it, which is an inevitable aspect of life in modern society.

In the book "*The Origin of a Network Society*," Manuel Castells [5] describes a network society as a specific form of social structure, characteristic of the Information Age. The vertical hierarchy between society and the state is being replaced; the rigid consolidation of roles and statuses is being replaced by horizontal, "flat" organizational structures of relations and relations between people and their informal, self-organizing communities. New values, norms, and standards are being formed: decentralization of management, reciprocity (reciprocal exchange on a natural basis) and nonequivalence of exchanges, building up weak ties between network members, etc. [18].

The social gift also takes a specific form in such a society.

Gratitude for services and assistance is no longer a "kickback" (so it was accepted in unregulated corporate relations) and, moreover, not a "tribute" (a traditional form of gift in vertical patron-client relations, where the client depends on the power of a powerful patron and fears sanctions for disloyalty to him). Moral obligations in a gift situation come to the fore. Interestingly, in a recent experiment, two different approaches to bribing public servants were investigated. The participants of the experiment could choose to call the payment offered to the official a bribe or a gift. The hypothesis that participants of the corruption relations prefer to call bribes gifts was refuted. Despite the fact that giving a gift seems preferable, since it looks less offensive and demanding, the results showed that many participants chose the term "bribe" precisely because it carries more obligations for the participants in corruption. The bribe clearly shows that the recipient is expected to receive mutual service, and, in case of opportunistic behavior, retaliation will follow [13].

The irrational, sacred nature of the gift does not depend on its price. Moreover, a social gift can lose its value if a person is too concerned about its price [7]. One study shows a difference in the perception of obligations imposed by gifts received in different situations. In western culture, there is a strong connection between the nature of the relationship between the participants of the gift exchange and the intention of the recipient to present a return. When participants are connected by personal relationships, these relationships and the symbolic meaning of the gift will be decisive for reciprocity, in contrast to the economic value or usefulness of the gift. For the situation of commercial gifts, the determining factor is the satisfaction of the recipient, which is often directly related to the utilitarian value of the gift [2].

The exchange of social gifts in a network society is non-equivalent in nature, which reflects the history of relations of the participants in the gift process (for short-term contacts, the importance of comparability of gifts is great) and their high emotionality, unofficiality. A number of studies emphasize that one of the main features of social networks is the visibility of users. Gifts are socially visible in nature. However, an additional level of visibility appears on the internet, making gifts between two users visible to any of their mutual contacts, which can increase the so-called social risk and deter users from giving online gifts through social networks [17]. On the other hand, a social gift was originally intended to be visible to a wide circle of people, therefore, an increased online visibility in this situation can have a positive rather than a negative effect.

In a 2018 study aimed at studying the distribution of online gifts, the authors also point out the significant role of social influence caused by the presence of observers. Among the mechanisms for distributing virtual gifts, the authors mention the expectation of reciprocity and social learning. The study shows that people quickly learn the observed norms of gift exchange on the network and that those who observed the exchange of online gifts among friends consider this behavior to be more normal than those who learned about such gifts from other sources or in person after having first received an online gift. The authors also note that virtual gifts can either replace or complement personal gifts: according to the results of the study, more than half of the gift cases would, in reality, not have taken place due to various obstacles to the personal exchange of gifts [12].

The variety of gifting situations and the low predictability of the development paths of these situations makes their algorithmization and, as a result, digitalization problematic. This problem is caused by the creative nature of the gift. "The giver has to make decisions in the face of a lack of time and information, as well as the unwarranted positivity of the consequences of their implementation" [9].

As was mentioned at the beginning of the paper, three paradigms to understanding the nature of donation can be distinguished: the economic exchange paradigm, the relational partnership paradigm, and the communal commitment paradigm. Gift exchanges on the Internet can be described in the framework of all three approaches, but most of the opportunities on the network are open for gift acts within different communities. According to researchers, this discovery can be used in marketing. Marketers can focus on P2P (person-to-person) marketing within potentially loyal communities with a developed gift-sharing culture, which will lead to group loyalty and provide a significant advantage for companies that target such communities [11].

In the context of the digitalization of many aspects of the life of a modern person, a social gift can be clothed in a modern—digital—form, and this trend also deserves careful study.

There are various approaches to the role and nature of online digital gift-sharing. Many researchers view digital gifts as an anti-economic activity; however, in a 2016 study, the authors dispute the correct use of the term "gift economics," while arguing that gift exchange and purely economic exchange are not mutually exclusive concepts, since they perform different functions and belong to two different universes. Gift exchange on the Internet is not associated with the exchange of goods, but with mutual recognition [16]. It should be noted here that when using the term "gift economy," the authors refer to M. Moss. However, Moss also believed that gift exchange can coexist with other types of exchange, in particular, with economic exchange in the markets. The anthropologist rather believes that even in a capitalist market economy, there is no purely economic rationality [10].

The authors propose distinguishing between three types of gifts: ceremonial gifts, graceful gifts, and mutual aid gifts. Only the last two types can be designated as truly anti-economic. Ritual gifts are not a manifestation of generosity; they are necessary to initiate and maintain a mutual recognition procedure. Digital gifts are a form of ritual gifts [16].

5 Conclusion

Based on various approaches to understanding the nature of donation: the theory of economic exchange, the theory of social partnership, and the theory of social obligations—we managed to comprehensively analyze the information and communication essence of the gift and the features of the social gift. A gift is a non-verbal means of communication, a carrier of encoded information about the giver, the recipient, and the gift situation itself. A social gift is characterized by a non-mercantile nature, the presence of a deep interest in creating, maintaining, and strengthening social ties.

The contradictory nature of the social gift in the information society is disclosed. The conclusion that, in the digital era, the forms and methods of social donation were transformed is substantiated. The following modern trends in presenting social gifts have been identified: moral obligations in the gift situation come to the fore, the symbolic meaning of the gift and its emotional aspect are increasing, gift exchange is not equivalent.

In the digital age, the following unique forms of social gifts appeared: virtual gifts (online gifts via social networks, which are characterized by increased visibility, which at the same time create new risks by their increased openness to outside observers) and gifts in digital form.

New hard-to-solve problems arise—the algorithmization and digitalization of social gifts makes it unlikely that the irrational component of the gift can be preserved, and the national identity of situations of social gifting is at risk. All these problems have to be addressed by modern generations of human resource managers.

References

1. Afanasyev, V.G.: Social information and society management. Political Publishing House, Moscow, USSR (1975)
2. Antón, C., Camarero, C., & Gil, F.: The culture of gift giving. What do consumers expect from commercial and personal contexts? J. Consum. Behav. **13**(1), 31–41 (2004)
3. Barsukova, S. Yu., Mutual assistance of Russian households: Theory and practice of the gift economy. Universe of Russia, vol. 2(8), pp. 81–122
4. Caplow, T.: Rule enforcement without visible means: Christmas gift giving in middletown. Am. J. Sociol. **89**(6), 1306–1323 (1984)
5. Castells, M.: The information age: Economics, society, culture. Higher School of Economics, Moscow, Russia (2000)
6. Dahl, V.I.: Explanatory dictionary of the living great Russian Language, 6th edn. Drofa, Russkiy yazyk-Media, Moscow, Russia (2011)
7. Fenko, A.B.: People and money: Essays on the psychology of consumption. KLASS Publishing House, Moscow, Russia (2005)

8. Graycar, A., Jancsics, D.: Gift giving and corruption. Int. J. Publ. Adm. **40**(12), 1013–1023 (2016)
9. Gryzova, U.I.: A gift as a carrier of social information. Bull. Orenburg State Univ. **11**(147), 190–195 (2012)
10. Heins, V. M., Unrau, C., & Avram, K.: Gift-giving and reciprocity in global society. Introducing Marcel Mauss in international studies. J. Int. Polit. Theor. **14**(2), 126–144 (2018)
11. Hollenbeck, C.R., Peters, C., Zinkhan, G.M.: Gift giving: A community paradigm. Psychol. Mark. **23**(7), 573–595 (2006)
12. Kizilcec, R.F., Bakshy, E., Eckles, D. & Burke, M.: Social Influence and reciprocity in online gift giving. In: Mandryk, R., Hancock, M., Perry, M., & Cox, A. (eds.). Proceedings from CHI '18: The 2018 CHI Conference on Human Factors in Computing Systems. ACM Press, New York, NY (2018)
13. Lambsdorff, J.G., Frank, B.: Bribing versus gift-giving—an experiment. J. Econ. Psychol. **31**(3), 347–357 (2010)
14. Levy-Strauss, C.: Structural anthropology. EXMO—Press, Moscow, Russia (2001)
15. Moss, M.: Society. Exchange. Personality. In: Proceedings of social anthropology. Publishing House "Book House University", Moscow, Russia (2011)
16. Romele, A., Severo, M.: The economy of the digital gift: from socialism to sociality online. Theor. Cult. Soc. **33**(5), 43–63 (2016)
17. Shmargad, Y., Watts, J.K.M.: When online visibility deters social interaction. The Case of Digital Gifts. J. Interact. Mark. **36**, 1–14 (2016)
18. Steinberg, I.E.: Psychology of nonequivalent exchanges in social support networks of urban and rural families. Bull. Publ. Opin. **6**(74), 52–57 (2004)

Agriculture of the Voronezh Region: Challenges and Prospects of the Digital Economy

Alexander V. Agibalov, Ludmila A. Zaporozhtseva, and Yuliya V. Tkacheva

Abstract Ensuring food security and the production of agricultural products remain relevant in the digital economy. Despite the significant role of advanced and innovative technologies, the Voronezh region, like the rest of the Russian Federation, is to face challenges and assess the prospects for the digitization of agriculture.

Keywords Digital economy · Agriculture · Innovation · Voronezh region

1 Introduction

The national program Digital Economy was adopted in accordance with the Decree of the President of Russia "On National Goals and Strategic Tasks of the Development of the Russian Federation for the Period until 2024" (May 7, 2018 No. 204). It was approved on December 24, 2018, at a meeting of the Presidium of the Council under the President of Russia on strategic development and national projects [9]. The digitalization of the Russian economy, in our opinion, is similar to such large-scale transformations as mass railway construction in the nineteenth century and the electrification of the country at the beginning of the twentieth century. Its implementation will allow us to make a "breakthrough into the future." Moreover, in this future, Russia is among the leaders in the quality of population life, the level of equipment of production with new technologies, and robotics. We believe that this is especially true for agriculture.

The Ministry of Agriculture of the Russian Federation in the framework of the implementation of this national program has developed a departmental project called Digital Agriculture. The digitalization of agriculture is of great importance for the

A. V. Agibalov · L. A. Zaporozhtseva · Y. V. Tkacheva (✉)
Voronezh State Agrarian University named after Emperor Peter I, Voronezh, Russia
e-mail: julchen19@yandex.ru

A. V. Agibalov
e-mail: agi-64@mail.ru

L. A. Zaporozhtseva
e-mail: ludan23@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_26

development of the economy of the Voronezh region. This is an urgent problem that requires immediate development regarding the introduction of digital technologies, both proposed by the departmental project and requested by the agribusiness. The Department of Agrarian Policy, the Government of the Voronezh Region, the Voronezh State Agrarian University named after Emperor Peter I (the leading agricultural university of the region), and all subjects of the agro-industrial sector are directly involved in its implementation on the territory of the Voronezh region. The pioneers of the digitalization of agriculture of the Voronezh region are LLC EkoNiva-APK holding, LLC Logus-agro, and the representatives of IT-Thematics (the winner of the competition for the implementation of the Unified Federal Information System for Agricultural Land in the Voronezh region). These entities were the first in the Voronezh region to implement the results of research, invest, and test new technologies. They are testing the methods of interaction between scientific organizations and governing bodies, and decisions on the adjustment of mass implementation models are being made.

2 Materials and Methods

The digital economy is viewed in many different ways, but in our opinion, its essential quality is its innovation in many areas of activity. The focus on digitalization involves not only the introduction of digital technologies but also the reengineering of all economic processes and financial relations [2]. Moreover, the main factor in the successful implementation of the chosen course is an investment in infrastructure development.

The digital economy can be represented as a unity of the following components:

- conceptual tools—the ideas and concepts that underlie the digital economy; the physical component of many critical constituent elements of the document and document flow, the nature of money turnover, and the protocols of cash flow and settlement are changing, and most importantly, the concept of a time lag disappears (for many processes, it is almost eliminated; for some, it no longer has such a significant effect);
- physical means—tools and processes of the digital economy that can be used to achieve any specific goal (tools—electronic payments, electronic services, etc.; processes—electronic data-circulation system, contactless interaction technology);
- digital infrastructure as a set of tools that serve the digital economy—protocols, legislative acts, means of protecting interests and resolving conflicts of interests of various user groups, etc.;
- gadgets—physical means of interaction within the framework of concepts of tools and processes based on the infrastructure component of digital technologies.

It seems evident that the transition to a digital economy requires high investment in these components. Gadgets, as the property of individuals and legal entities, determine the availability of the digital environment. Therefore, their development is determined by the ratio of supply and demand. The formation of the digital economy's infrastructure is impossible without government participation and consideration of world practice and interests.

The main goal of the digital economy is the digital transformation of agriculture through the introduction of digital technologies and platform solutions to ensure a technological breakthrough in the agricultural sector, and to achieve a two-fold increase in labor productivity in "digital" agricultural enterprises by 2021 [4]. If we consider the methods as a set of ways to achieve this goal, then at the first stage, it is necessary to analyze the existing potential of the digitalization.

The Voronezh region, as a platform for the implementation of the digital economy, is predominantly agricultural and mixed in terms of industry structure. According to the results of 2018, in the Gross Regional Product of the Voronezh region, agriculture owns 123,702 million, the processing industry 120,000.8 million, and trade 163,665.7 million. In 2018, crop production in the Voronezh region accounted for 60% of all agricultural output, and livestock accounted for 40% [5].

According to the 2016 Russian Agricultural Census, the region's agribusiness includes more than 700 agricultural organizations, more than 2500 peasant farms and individual entrepreneurs, more than 400,000 personal subsidiary farms of citizens, and more than 100 food and processing enterprises [10].

Considering the organization of production and technology, it is worth noting that the region uses such methods of accurate agriculture as determining the boundaries of fields using satellite navigation systems, parallel driving, satellite monitoring of vehicles, differentiated spraying of weeds, differentiated fertilizer application, differentiated irrigation, monitoring the quality of livestock products, electronic database of the production process, monitoring the condition of the herd, identification, and monitoring of individual animals using modern information technologies (feeding ration, milk yield, weight gain, body temperature, activity), and milking robots.

The region is an industrial center where manufacturers of a wide range of high-tech industrial products are concentrated. Voronezh enterprises produce airplanes, rocket engines for space technology, equipment for the mining, oil, and gas industries, forging machines, synthetic rubber, car tires, bridge structures, complex electronic complexes, building materials, various food products, and other types of products.

Further development of digital technologies requires an assessment of the data of pilot organizations of the transition to mass implementation of the presented mechanisms and projects. Moreover, from the point of view of science, it is necessary to use not only general scientific (synthesis, descriptions, abstractions) but also economical methods: economic modeling, statistical, and economic methods. Solving specific problems requires unique methods synthesized at the junction of several sciences.

Generally, as applied to regions, one can single out the existence of general and specific methods and algorithms for the digitalization of agriculture.

Among the general ones, the need to create a digital agricultural space in the form of databases, new descriptive methods, and programs to be singled out. The methods of ensuring the objectives of production growth, which are associated with the specialization of the territories, are specific.

Currently, agriculture is being informatized, land resources are being digitized, and electronic records of animals and their movements are being introduced. The entire production process from sowing to sale is described in databases and allows us to obtain data on the status and stage of production anywhere in the region.

The mechanisms of stabilizing agricultural production in different climatic zones of the region are of particular importance.

3 Results

Digitalization is implemented in several stages, in which timing is adjusted, following the unfolding horizons and prospects. Currently, the basic directions of the digital transformation of agriculture have been developed as part of the departmental project of the Ministry of Agriculture of the Russian Federation "Digital Agriculture," which include the following areas:

- Effective hectare. It provides an inventory of agricultural land through the Unified Federal Information System on Agricultural Land (ever after referred to as UFIS AL), with further filling in data on soil characteristics, climate, appropriate seed selection, yield, proximity of processing capacities, logistics, balance of domestic production and consumption for micro and macro level, and export options. UFIS AL will be integrated with the bases of Rosreestr and Roskosmos, which will provide a high level of verification to the map of agricultural land. This will make it possible to introduce intelligent industry planning in 85 constituent entities of the Russian Federation (100%) by 2021 on the principle of growing the most profitable crops, taking into account the transport leg to the place of processing or consumption.
- SMART contract. It provides the creation of an intellectual system of government support measures and personal accounts of the recipient of the subsidy. Russian Agricultural Bank will provide opportunities for electronic identification of farmers in the Unified Identification and Authentication System. The operator company of this system will provide package solutions for agribusiness (subsidy + credit + insurance). The integration with the bases of Roshydromet and the Ministry of Emergencies will allow adjusting subsidies on emergencies in the regions. By 2021, 100% of contracts with subsidy recipients will be concluded in the SMART regime.
- Agroexport. The "Effective hectare" will allow simulating real-time export flows of agricultural raw materials. The integration with the bases of Roshydromet and the agrochemical centers will make it possible to make an accurate forecast of yields and harvesting dates. It is planned to link forecasted yields with the rolling stock of Russian Railways to break up bottlenecks, taking into account the limitations of freight nodes.
- Agro solutions for agribusiness. The organized scaling of domestic integrated digital agricultural solutions for agricultural enterprises is planned: "Smart Farm,"

"Smart Field," "Smart flock," "Smart greenhouse," "Smart Recycling," "Smart Warehouse," and "Smart Agrooffice." By 2021, 100% of agricultural products for export will be accompanied by a paperless system, from field to port.

- "Land of Knowledge"—55th digital agricultural university. The first branch quasi corporate electronic educational system "Land of Knowledge" will be created. Fifty-five thousand specialists of domestic agricultural enterprises will be trained in digital economy competencies from 2019–2021 [1, 6–8].

In the Voronezh region, the above areas are being actively implemented. In 2018, 1.5 million were allocated from the regional budget for the implementation of activities under the "Effective Hectare." An average of 92.4% of the contours was filled with relevant information (TIN, name of the land user, seeded crop for the harvest of 2018). The work was carried out by the organization Aichi-Thematic LLC, which was selected on a competitive basis. In 2019, the work to fill in the UFIS AL continued. For these purposes, the regional budget provides 1.8 million. However, it should be noted that these programs are underfunded due to the scale of the activities.

The technical specifications for the provision of services for the formation, aggregation, and processing of information on agricultural lands and lands used or provided for farming as part of lands from other categories (including information on the location, condition, and actual use of such lands, located on the territory of Voronezh regions) is to fill out a unified federal information system for processing; information about agricultural lands (UFIS AL) for the 2019 is being prepared.

Currently, at the municipal level, UFIS AL is filled with information on winter crops for the 2019 harvest. The work is carried out in close cooperation with the agrochemical service of the region, using this software to assess the condition of winter crops.

The next task to fill in the UFIS AL is the prompt entry of information at the end of the spring sowing in 2019. The Department of Agrarian Policy of the Voronezh region will set specific deadlines for entering data for each district. We believe that the consumer will soon be able to receive information—not only about the national origin of the product but also the technology of its production and storage [3].

In the direction of "Agro-solutions for agribusiness," the AgroPole project has been developed—an automated system (AS) that allows planning, accounting, reporting, monitoring of production activities, and analysis of the effectiveness of an agricultural enterprise. In 2016–2018, it was gradually introduced on the basis of Logus-Agro LLC (Novousmansky district). In April 2018, a quadripartite agreement on cooperation in the field of innovative development of information technologies in the agricultural sector was signed between the Government of the Voronezh Region, the Voronezh State Technical University, the Voronezh State Agrarian University, and Logus-Agro LLC.

A decision at the federal level is expected in the areas of "SMART contract," "Agroexport," and "Knowledge Land." Within this decision, open access for interested persons is anticipated. At the same time, the introduction of digital technologies in the payment of subsidies is being discussed.

4 Discussion

Currently, the Department of Agrarian Policy, the Government of the Voronezh Region, the Voronezh State Agrarian University, and representatives of agribusiness are taking an active part in meetings of the Ministry of Agriculture of the Russian Federation in the videoconferencing regime on the topic: “Digital transformation of agriculture of the Russian Federation: joint work of the Ministry of Agriculture of Russia and regional agro-industrial complex management bodies”; Government of the Voronezh region on the topic: “Digital transformation of agriculture in the Russian Federation: the introduction of innovative digital solutions and technologies as part of integrated automated systems”; and others.

On these platforms, the most effective mechanisms for the introduction of advanced achievements and technologies are actively discussed; the models for the development of digital infrastructure are elaborated; zones of responsibility of the authorities and business owners are formed, and the importance of the efforts of each subject in moving towards the final result is stipulated.

5 Conclusion

Nowadays, there is no longer a question of “why” the digitalization of the economy and agriculture is needed. It is essential to understand how to do it quickly and efficiently, given the challenges of time and business. Also, the financing of the process and its effectiveness must be taken into account. The digital development of agricultural enterprises of the Voronezh region is based on the principles of innovation, import-substitution, the introduction of new advanced technologies, the creation of qualitatively new types of products, implementation of cluster initiatives, creation of high-performance jobs.

Digitalization of agriculture is possible, only with the use of collective thinking of agricultural economists, authorities, business representatives, as well as programmers specifically focused on the agricultural sphere of activity, who have special knowledge about the activities of agricultural enterprises, and who are well aware of the technological processes of agricultural production. Behind the digitalization of the agricultural economy is the high-tech agribusiness of the future.

Acknowledgements The authors would like to express their gratitude to the Department of Agrarian Policy of the Voronezh region for providing relevant information and assistance in scientific research.

References

1. Agenda, F.A.O.: Digitization of the AIC and climate-optimized agriculture. Agric. Sci. **6**, 43–44 (2018)
2. Chernobay, N.B.: Digitalization in agriculture. Financ. Econ. **8**, 265–270 (2018)
3. Demmel, M., Gandorfer, M.: Who sows data. New Agric. **6**, 40–43 (2018)
4. Digitization of Agriculture: Feed Prod. **7**, 5–6 (2017)
5. Economic Development Department of the Voronezh Region: Official Website (n.d.). Retrieved from https://econom.govvrn.ru
6. Government of the Russian Federation: The decree "on approval of the digital economy of the Russian Federation program" (July 28, 2017 No. 1632-r). Moscow, Russia (2017)
7. Government of the Russian Federation: Resolution "On amendments to the resolution of the Government of the Russian Federation" (July 14, 2012 No. 717). Moscow, Russia (2019)
8. Ognivtsev, S.B.: The digitalization of the economy and the economy of digitalization in agriculture. Int. Agric. **2**, 77–80 (2019)
9. President of the Russian Federation: The decree "On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024". (May 7, 2018 No. 204). Moscow, Russia (2018)
10. Territorial body of the Federal State Statistics Service in the Voronezh Region: Official website (n.d.). Retrieved from https://voronezhstat.gks.ru

The Adoption of Technological, Service, and Business Model Innovations in Complex Systems

The Analysis of the External Environment to Determine the Practical Focus of Applied Research and Development in the Framework of Innovation

Alexander S. Samusenko, Nataliya S. Plaskova, and Natalya A. Prodanova

Abstract Nowadays, innovation plays an important role not only as a catalyst for the global progress of humanity but also as an additional opportunity for a commercial organization to strengthen its position in markets of any level. For this purpose, an organization must take into account external conditions that can significantly affect the innovation process and the results of innovation. Since innovation is inherently quite complicated in an organization, being a resource-consuming process, it is essential to implement innovative projects following the needs of consumers of innovative products. Therefore, for the implementation of commercially effective innovative projects related to the production and sale of innovative products in the form of goods, works, and services, an important stage is a competitive analysis of the external environment, including the formation of conclusions and recommendations on the practical orientation of applied research and development in the organization to meet community needs. For this purpose, the authors consider the methods of analysis of the external environment. The paper focuses on the presentation of the advantages of applying the PESTEL analysis methodology, which is a modified version of the PEST analysis; the methods of PESTEL analysis for conducting innovative activity are described.

Keywords PESTEL analysis · Environmental analysis · Innovative activity · Research and development

A. S. Samusenko · N. S. Plaskova (✉) · N. A. Prodanova
Plekhanov Russian University of Economics, Moscow, Russia
e-mail: Plask55@mail.ru

A. S. Samusenko
e-mail: Alexander.samusenko@aiesec.net

N. A. Prodanova
e-mail: prodanova-00@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_27

1 Introduction

The choice and adherence to the strategy of innovation activity requires a fairly broad look at the whole set of indicators characterizing the level of development of social, economic, and other spheres of society, with a level of technological development not only at the micro-level but also on the scale of the whole state, up to the integration of the world community. In this regard, even at the planning stage of innovative activity, the research direction should be chosen, which will be further implemented as part of the implementation of the innovation project.

The place of applied research and development can be represented at the stage of the life cycle of an innovation project. According to Russian scholars, the life cycle of an innovation project contains five main stages [1].

- Scientific and technical activities, including:
  - basic research;
  - applied research;
  - development work;
- Implementation;
- Growth;
- Maturity;
- Decline.

At the same time, fundamental research and development follows the formation of an organization's innovation strategy but is not yet tied to specific innovative projects. Thus, fundamental research and development have a general character, and the practical orientation of innovation is already formed in the transition to the stage of applied research and development. It is necessary to set a whole vector for the development of innovations before conducting applied research and development. For this purpose, it is necessary to analyze the conditions of the implementation of innovations. For product innovation, this is an environmental analysis.

The practical orientation of the research is formed on the basis of basic research. According to Khubulava and Larionova, based on an innovative strategy, the stage of applied research and development is preceded by the following four procedures by the technical specialists of the organization [3]:

- technology assessment,
- the justification of the weak and strong sides of technology,
- the design of new technological processes, and
- a comparison of the results of the study.

However, the innovation strategy requires a broader view of innovation in general. The design of new technological processes and the comparison of the results correspond to the development of a business plan for an innovation project and the selection of the most attractive innovation project to be implemented [4]. These steps can be applied to describe the sequence of the transition of the generalized results of basic research to applied research [2]. However, this mostly applies to technology assessment and justification of its strengths and weaknesses.

2 Materials and Methods

In order to choose the most appropriate method of analysis of the external environment, necessary for the transition from the stage of fundamental research to applied development, the scientific works of Russian and foreign economists were studied. The possibilities of using the methods proposed by the authors are analyzed. The conclusions on the adaptation of the proposed methods to innovation are summarized and systematized.

Based on these procedures, it is concluded that it is advisable to analyze the external environment, including the study of the political, economic, and social conditions of the macroenvironment. Therefore, to determine the direction of applied research and development, the methodology of PEST analysis (P—political, E—economic, S—social, T—technological) should be applied for the analysis of the political, economic, social, and technological external factors that affect the implementation of innovations.

The application of the PEST analysis is the most promising method for studying the external environment at the stage of transition to applied research. However, in addition to studying the four types of macroenvironment, the environmental factors and the regulatory framework should be added to the classical PEST analysis, since product innovation and innovative processes must comply with environmental standards. In turn, the innovative products and their production must comply with regulations at all administrative levels. In this regard, it is advisable to apply a modified PEST analysis, i.e., a PESTEL analysis (E—ecological, L—legal) as a combination of environmental factors such as political, economic, social, technological, environmental, and regulatory factors.

Even though conducting a PESTEL analysis is very time-consuming, it makes it possible to evaluate the possibilities of innovative activity in a specific direction to the greatest extent.

3 Results

The PESTEL analysis comprises a sequence of steps. This technique is described in the work of Ponomareva, “Methodology for PESTEL analysis”; however, it must be modified in accordance with the requirements of innovation. Thus, in order to conduct an analysis, it is necessary to perform the following steps sequentially [6]:

1. Determine the limits of the level of the environment to be investigated. For innovation activity, the most significant role is played by the analysis in the following borders;

   - The analysis of the political environment (the key level of this study is the state level);
   - The analysis of the economic environment (should include analysis of all levels, from the development of potential markets to global economic trends);
   - The analysis of the social sphere (most relevant to social development in the country and region);
   - The study of the ecological environment (the study is most appropriate within the region and municipality);
   - The study of legal acts in compliance with legal norms at all levels;
   - The analysis of the technological sphere must be moved beyond the scope since applied research is already being carried out on the basis of fundamental activity after determining the direction and vector of technological development.

2. Define a list of factors in each of the five areas that can influence the organization's activities in the current environment. The number of factors taken into account in each area may vary depending on the organization's type of activity. Nevertheless, a greater number of studied factors leads to an increase in the complexity of the study, but it can positively affect the conclusions of the study.
3. Each of these factors, regardless of the field of research, should be evaluated by three parameters:

   - Determine the nature of the influence of the factor (positive or negative) on the organization, market or industry as a whole;
   - Assess the strength of the influence of the studied factor on the organization, market or industry using the method of expert opinion (for greater variability, it is recommended to do it on a 10-point scale);
   - Identify the degree of certainty of the factor in the process of implementation of innovation.

When the environmental factors are evaluated, a comprehensive assessment of the influence of external factors on the results of research in the framework of innovation is made. The influence force is added to the specified trends with the sign defined when specifying the influence vector of this factor. In this case, for uncertain factors, the influence force is adjusted in accordance with the probability of the event (the influence force for uncertain factors is summed with the probability coefficient for uncertain events, adjusted downwards by 0.5).

Thus, as a result of the study, trends with the largest comprehensive assessment are identified. The organization should transfer these trends to the plane of applied research to assess the most promising direction of innovation.

It is essential to pay attention to the fact that for innovation activity, the analysis of the organizational and technical level in dynamics is almost irrelevant, since the

Table 1 PESTEL-analysis determining the direction of innovation development

No	Factor	Description	Influence vector	Influence power	Degree of certainty
1	…	…	+ /− (positive/negative)	0–10	Defined/Not defined
2	…	…	…	…	…
3	…	…	…	…	…

Source Ponomareva [6]

dynamic and normative analysis of indicators explores the current deviation from basic and normative indicators, while innovation activity deals with exclusively new or modernized technological and organizational processes. For this reason, the results of failure to meet the target or deviation from last year's performance have a weak link with innovation and refer to management activities. As part of the choice of the direction of applied research, the study of dynamic performance indicators of production processes allows us to identify stagnant processes that have no defined reserve of efficiency, but, according to PESTEL analysis, have a promising direction.

Since PESTEL analysis within the framework of innovation is the analysis of five areas of social development that takes into account fundamental research and development, an analytical table is formed to display the results of the PESTEL analysis and the assessment of the factor from the point of view of the influence vector, strength of influence and degree of certainty. A typical table for conducting PESTEL analysis as part of a preliminary assessment of external factors is presented in Table 1.

After a preliminary assessment of the factors influencing the development of innovation, a comprehensive assessment of the impact on the main trends of further practical developments should be calculated. This assessment should be based on the results of basic research and global scientific and technological trends. In this case, depending on the influence of the studied factors on the research results, a complex assessment of the influence of external factors on innovative solutions was calculated. A typical analytical form presented in Table 2 was also prepared for this purpose.

Table 2 The influence of external factors on innovative solutions

No	Trends identified in a technological research organization	Comprehensive assessment of the influence of external factors
1	…	…
2	…	…
3	…	…

Source Ponomareva [6]

4 Discussion

The practical application of the presented methodology for conducting PESTEL analysis can be considered on the basis of the conditional enterprise Khimprom, engaged in the production and sale of household and industrial detergents. When deciding to expand the product range and research in this area, it is necessary to account for the influence of the factors indicated in Table 3.

The factors listed in Table 3 are not fully capable of influencing decisions on innovation. Therefore, in Table 4, only the factors influencing the specified trend are summarized by the identified trend.

As a result of studying the external environment based on a comprehensive assessment of the influence of external factors on the nature of applied research at Khimprom, we can conclude that a method for collecting used detergent and cleaning it for secondary use should be developed.

Despite the fact that not all factors listed in Table 3 have a direct impact on innovation (in this example, the main emphasis is made on environmental factors affecting the organization), the political, economic, and social factors have an indirect effect on the development of innovation activities in the form of integration with suppliers of materials, delivery costs, and the purchasing power of the population. For this reason, PESTEL analysis requires a thorough approach, allowing the identification of the most promising area of the applied research.

In larger-scale activities of an enterprise, options for innovative solutions can be much more profound, and the number of factors can be much greater. Moreover, PESTEL analysis is the first stage of analysis when choosing a decision on the direction of applied research and anticipating opportunities within the organization itself.

5 Conclusion

The results of basic research should be continued as part of innovation in the form of applied research and development in accordance with the trends identified at the various levels as a result of the PESTEL analysis. Researchers must consider the identified opportunities and threats in order to avoid excessive risks and increase the effectiveness of innovation.

Also, if PESTEL analysis is the basis for decision-making on the implementation of product and marketing innovations, in which commercialization is based on the implementation of an innovative product to external users, then a comprehensive analysis of the organizational and technical level plays an important role in the implementation of organizational and marketing innovations [5]. Nevertheless, PESTEL analysis, regardless of the type of innovation, allows the determination of the primary vector of innovative projects that are just starting to be developed based on the results of basic research.

Table 3 PESTEL-analysis of the conditional enterprise "Khimprom" producing household and industrial detergents

No	Factor	Description	Influence vector	Influence power	Degree of certainty
Political factors					
1	Tensions with developed countries	Tensions with developed countries lead to decreasing cooperation with them, including in technology sectors	–	5	Defined
2	Tightening state control	In various areas of society, there is an increase in government control	–	4	Defined
Economic factors					
1	Growing influence of Southeast Asian states	A gradual displacement of world financial centers leads to increasing trade with Asian countries	+	3	Defined
2	Budget deficit in Russia	Budget deficit in Russia can lead to the tightening of financial control over the activities of commercial organizations	–	6	Not defined

(continued)

Table 3 (continued)

No	Factor	Description	Influence vector	Influence power	Degree of certainty
3	Differentiation of population incomes	At the moment, there is a huge difference in the income level, depending on specific criteria	–	4	Defined
Social factors					
1	Social stratification of society	The country has an unequal access to benefits for different segments of the population	–	4	Defined
2	Urbanization	A rapid growth of the urban population in relation to the number of rural residents	+	6	Defined
3	Support of socially vulnerable population	There is an improvement of the material base observed in the country, taking into account the needs of socially unprotected layers of the population	+	3	Not defined
Environmental factors					

(continued)

Table 3 (continued)

No	Factor	Description	Influence vector	Influence power	Degree of certainty
1	Strengthening the role of renewable materials	In a global sense, there is a tendency to use recyclable products of natural origin	+	9	Defined
2	The use of synthetic materials based on natural components	The use of natural components in the production strengthens the position due to the absence of significant harm to the environment	+	9	Defined
3	The course on reducing harmful emissions into the ecosphere	There is a tendency to reduce harmful emissions into the atmosphere and hydrosphere of materials used in production	+	8	Defined
Legal factors					
1	The amendments to environmental legislation	In connection with the strengthening of control by the state, it is possible to tighten administrative law in the field of environmental protection	–	7	Not defined

(continued)

Table 3 (continued)

No	Factor	Description	Influence vector	Influence power	Degree of certainty
2	The variability of application of preventive measures in case of violation of regulatory law	The interpretation of preventive or punitive measures as a result of the application of regulatory law is not always the same, and often decisions are made at the discretion	–	3	Not defined
3	The compliance with labor law in hazardous industries	In chemical industry organizations, there is a rigid control over observance of the labor law in conditions of harmful production	–	6	Defined

Source Developed by the authors

Table 4 The influence of external factors on innovative solutions

No	Trends identified in a technological research organization	Comprehensive assessment of the influence of external factors
1	Development of a solid-state detergent for glasses with a minimum amount of waste	6,5
2	Development of universal detergent for all types of synthetic and natural materials	0
3	Development of a method for collecting waste detergent and cleaning it for secondary use	10

Source Developed by the authors

References

1. Bovin, A.A.: Innovation management in the organization. Omega-L, Moscow, Russia (2009)
2. Khosravi, P., Newton, C., Rezvani, A.: Management innovation: A systematic review and meta-analysis of past decades of research. Eur. Manage. J. **37**(6), 694–707 (2019)
3. Khubulava, N.M., Larionov, N.M.: Innovative strategy. Controlling **50**, 12–19 (2013)
4. Liu, C., Lin, B., Shu, W.: Employee quality, monitoring environment and internal control. China J. Acc. Res. **10**(1), 51–70 (2017)
5. Lysenko, D.V.: Comprehensive Economic Analysis of Economic Activity. Infra-M, Moscow, Russia (2010)
6. Ponomareva, A.V.: The methodology of PESTEL analysis. Econ. Soc. **11–2**(30), 264–270

Innovation and Structural Transformation of Industry

Victor I. Mysachenko, Vyacheslav Y. Komarov, and Konstantin Y. Reshetov

Abstract The innovative activity of the production system is the most important component of its successful adaptation to rapidly changing market conditions, expressed in the increasing competition in the domestic and foreign markets. Innovation is one of the main structure-forming factors in micro-, meso-, and macroeconomic levels, which finds its practical embodiment in the evolution of structural changes in the industrial and post-industrial economy. At the same time, at the industry (mesoeconomic) level, innovations are formed due to such important components as strategic planning, scientific and design activities, and marketing research. The paper focuses on the main factors of innovative development of industrial production. A comparative analysis of the components of innovation activity of developed and developing countries (BRICS countries) is carried out. The paper shows both weak and strong competitive positions of the Russian economy in the innovation sphere, reveals its features. The criteria for classifying the industry as a knowledge-intensive one are defined and disclosed. Characteristic features of knowledge-intensive industries and knowledge-intensive manufacturing, the growth of the share of which leads to progressive structural transformations of industry, increase its competitiveness. Particular attention is paid to structural transformations at the microeconomic level, where the liquidation of inefficiently operating enterprises, the creation of new knowledge-intensive companies, as well as the restructuring of existing ones, allow the implementation of a whole range of progressive transformations, such as financial, industrial, property, managerial, and legal ones.

V. I. Mysachenko (✉) · V. Y. Komarov
National Institute of Business, Moscow, Russia
e-mail: mysviktor@yandex.ru

V. Y. Komarov
e-mail: sl.komarov@gmail.com

K. Y. Reshetov
National Institute of Business, Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
e-mail: konstantvip@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_28

Keywords Innovation · Innovative development · Knowledge-intensive industry · Restructuring · Structural transformations

1 Introduction

Innovative processes make up an increasing share in the structural renewal of industry and the formation of a post-industrial economy. The formation of a new branch structure of industry is characterized by the growing role of scientific and technological progress and innovative factors of production. An increase in the share of knowledge-intensive industries and industries in the industrial sector of the economy and the reduction in the share of traditional types of production can accelerate the formation of a progressive industry structure and increase its competitiveness [2].

The purpose of the study is to identify and systematize the main factors of innovative development of industrial production, leading to the growth of knowledge-intensive industries and those in the updated structure of industrial production.

The objectives of the study are to determine criteria for classifying the industry as science-intensive, disclose its characteristics, analyze strong and weak competitive positions of the Russian economy in the innovation sector, and justify its features.

2 Materials and Methods

According to economists S. Yu. Glazyev, G. A. Eremenko, Yu. V. Yakovtseva, et al., technological innovation is the basis of sectoral structural transformations that form a new, progressive industry structure. It is the technological modernization of the industry, along with the accelerated development of the services sector, that nowadays is one of the most important factors in the country's accelerated movement towards a post-industrial economy. At the microeconomic level, structural transformations are implemented through the liquidation of inefficiently-functioning companies and various types of restructuring of existing enterprises: production, financial, property, organizational, legal, and managerial. At the same time, each of the mentioned types of enterprise reorganization involves the active introduction of innovations leading to radical transformations of a particular sphere of the production system. In this regard, in a number of studies (Krylova, E. B., Lyutova, I. N., Mironova, N. N., Pirogova, N. L., Sanina, N. V., Staurina, G. N., Timofeeva, M. I., Shutkova, A. A., et al.) it is noted that the development of innovative and knowledge-intensive industries is currently the main line of business, which is based on the constant search and implementation of modern forms, methods, and tools to increase the capabilities of companies under dynamically changing external conditions. Meanwhile, the innovative activity of the domestic industrial sector of the economy is at a relatively low level, which provokes the conservation of the outdated technological and sectoral structure of the industry.

The process of studying the impact of the innovation sphere on structural transformations in industries was based on the collection and synthesis of materials on the theory and practice of structural updating of industries and restructuring of existing enterprises. In order to systematize the results of the study, the following methods were used: scientific knowledge, analysis and synthesis, systemic and integrated approaches, structural analysis, and statistical analysis of empirical data. The research methodology was based on the approaches and provisions of the neoclassical and neo-Keynesian models of economic growth. The informational basis of the study was as follows: the statistical reporting of Rosstat, economic reference books, statistical and analytical materials of research institutes, domestic experience of structural transformations in industries, periodicals, Internet resources, programs on economic and social development, as well as economic and sociological studies by foreign and Russian authors on the problems of industrial restructuring. The theoretical basis was the work of Russian and foreign researchers on the problems of state regulation of innovative and structural processes.

3 Results

The innovative sphere of industrial production plays a special role in the structural renewal of the industrial sector, since it transforms a scientific and technical product based on the results of scientific research and experimental design work into marketable products with qualitatively new properties, with an increase in scientific participation and weight in the receipt of the final product.

Thus, the formula for increasing innovation and the growth of scientific and technological progress (STP) in a simplified form can look like this:

$$\mathrm{STP} = \mathrm{AST} + \mathrm{STI}, \tag{1}$$

where

AST the advances in the development of science and technology and
STI scientific and technological innovations (implemented, results of the effective implementation of AST) [7].

In each individual national economy, the intensity parameters of creating innovative products are independently adopted, thereby ensuring their own competitive advantages. The impact of the innovative approach on production, according to some expert estimates, can vary from 70 to 85% of the gross domestic product growth. Therefore, it is no coincidence that knowledge-intensive resources are today attributed to developed factors whose use allows scientific and technological breakthroughs and generates progressive structural shifts in industry. The integration of science-intensive resources into a single scientific and production chain helps open up access to global markets for national companies, increase the competitiveness as well as the cooperation within industries, and the development of knowledge-intensive industries that ultimately contribute to the formation of a progressive structure of industries.

The total quantitative and qualitative indicators of the innovation economy are largely determined by scientific and technological breakthroughs based on scientific research. Innovation is now becoming more resource-intensive, complex, and diverse. As practice shows, the actual implementation of innovations in the process of introducing scientific and technological achievements is manifested, first of all, by determining the quantity and quality of resources for these purposes. Thus, if we consider innovation from a cost perspective, then the average cost of basic science-intensive research and development is many times higher than the cost of scientific and development work. Moreover, the creation of an innovative new product, the development of a new technological chain, and the development of new market sectors due to this, may require two-orders-of-magnitude-large investments. The fact that the increase in the need for innovative development and the implementation of innovations entailed a comparable increase in the cost of innovation itself is indicative of the costs of innovation introduced into technological processes in the last decade. Therefore, not all countries can afford growing budget expenditures for creation, modernization of the necessary infrastructure, and for the implementation of the stimulation of innovative knowledge-intensive activities.

However, as foreign experience shows, the import of technologies and the inflow of foreign capital for technological re-equipment of production are effective when the country's economy is actively included in international economic relations. In this case, symmetrical economic ties will increase the interest of exporting countries in the export of capital and technology to this country [3].

This became especially evident during the period of economic sanctions applied to the Russian Federation, when in a number of industries, there was a shortage of individually imported components, materials, and raw materials. In this regard, at present, integration with international scientific and production chains is very difficult.

In most countries with a post-industrial economy, the scale and sources of financing research and development are increasing, and their returns are also increasing. The largest role in the effective use of knowledge-intensive innovative technologies and in the economic growth of countries with post-industrial economies is played by the cooperation of general and internal science and the real sector of the economy. At the same time, part of the scientific work is transferred to private and state laboratories and universities, research centers, and institutes, which helps manufacturing enterprises develop their own innovative potential while remaining at the center of flows of scientific and technical information. With this approach, new systems of circulation of scientific developments and innovations are formed that are aimed at their commercialization.

In this regard, the position of the BRICS countries in stimulating innovation activity is of interest. Over the past decade, the total share of the BRICS countries in the global production of knowledge-intensive products has grown from 6 to 31%, the share of NAFTA has decreased from 40 to 30%, and the share of EU countries has decreased from 22 to 17% [4]. Such dynamics are explained, first of all, by the growing innovative positions of the PRC economy. As for Russia, it lags behind in terms of the development of factors related to the introduction of innovations and new business processes, as well as the quality of doing business (the quantity and quality of suppliers, the level of development of innovation clusters, the nature of comparative advantages, the depth of production processes in creating value chains, and quality management). As a result, the economy of the Russian Federation as a whole is in 52nd place in the global innovation index of the countries of the world. The weaknesses of the competitive position of Russia include scientific institutions (97th place in the world), the degree of development of the innovation market (76th place in the world), infrastructure (73rd place in the world), and the results of creative work of scientists (75th place in the world). Therefore, it is not a coincidence that, given the existing scientific potential in the country, only about 9% of industrial enterprises go to the development and development of innovations.

In turn, the strengths of the Russian economy are related to the quality of scientific results—34th place in the world; with the quality of human capital—38th place in the world; business development—37th place in the world [4]. The modest position of our country in the field of R&D and innovation, in recent decades, is explained primarily by a shortage of financial resources, a decrease in revenues to the state budget due to the sale of hydrocarbons, difficulties in transformation processes during the formation of a mixed economy, etc. The processes of disintegration in the period of market transformations had a significant impact on the lag in the development of domestic science-intensive industries. The transitional economy in this period looked disproportionate. The market volume significantly exceeded the ability to fill it with high technologies and research innovations that contribute to the development of a competitive economy.

The consequences of the collapse of the USSR and the new economic situation forced most enterprises to purchase many types of raw products and materials abroad. The key problem in the economy of the Russian Federation from the period of a planned economy has remained the same: the relatively low technical and technological security of production activities. The Russian economy has not recovered from the devastating effects of post-perestroika changes. Most of the industries had almost stopped their innovative development. The number of organizations capable of carrying out research and development has significantly decreased, as well as the number of design bureaus, design institutions, researchers, and technicians. However, the more researchers work in the field of R&D and the higher their productivity, the higher the activity of innovation and the efficiency of the use of business funds and the state budget in the innovation sphere.

Consequently, in the development of national innovation systems, a number of features are manifested, as well as the impact of key factors. For the Russian Federation, firstly, this is a lag in the formation of a number of elements of modern innovation infrastructure and insufficient development of innovation infrastructure institutions. Secondly, it is weak innovation activity within organizations. Thirdly, it is the low interest of industrial companies in innovation and the weak position of enterprises in the innovation culture. Finally, there are no stable interconnections in the innovation process between the main subjects: the state, firms, and scientific institutes [8].

In this regard, the most important factor in the innovative development of science-intensive sectors of the domestic economy is the strengthening of the financial interaction of business investments and budget investments—public–private partnerships in the implementation of innovative projects. Industrial companies in this interaction combine production factors (basic, developed, general, and special), which determines the type of economic development—extensive or intensive—that is carried out through the use of quantitative or qualitative factors of production and the use of traditional or modern technologies and high-performance equipment.

Another important factor in innovative development may be the focus of investments on technical re-equipment, equipping production with more advanced equipment and technologies. In this regard, it will require significantly increased costs for financing domestic knowledge-intensive industries and the development and implementation of technological innovations [1].

Industries, where science-intensive technologies prevail and play a key role, are referred to as science-intensive industries.

The knowledge-intensive industry (KI) can be defined as the ratio of the costs (C) for the introduction of scientific and technological achievements to the cost of products (CP) of this industry—the indicator of knowledge intensity [5].

$$\mathrm{KI} = \mathrm{C}/\mathrm{CP} * 100\% \tag{2}$$

The scope of R&D in the industry forms the need for scientific research for the production of an innovative product.

The characteristic features of knowledge-intensive industries are as follows:

- the emergence and use of qualitatively new technologies used in the production, organization, management, and marketing of knowledge-intensive products, etc., the presence of higher rates of development compared to traditional industries;
- accelerated investment and employment growth;
- integrating influence on the functioning of traditional industries in terms of using a more progressive production apparatus;
- increasing the competitiveness of manufactured goods and services, increasing the share of knowledge-intensive products in the domestic and foreign markets.

It should be noted that the main knowledge-intensive developers of innovations in industrial sectors used to be the research institutes of Russia—industrial research organizations, academies, and universities, and, to a lesser extent, industrial companies themselves. Currently, the share of individual research and private development companies has increased, as well as the share of developments directly at industrial sites, bypassing research institutes [6].

4 Discussion

The current stage of structural transformations of the domestic industry is characterized by active restructuring at the microeconomic level, an increase in the importance of the activities of science-intensive companies and an increase in their competitive advantages, since the expansion of the innovative sphere and the dynamics of the use of modern technologies in the economy form fundamentally new scientific, technical, and economic production capabilities of the national industry. Innovatively developing companies increase material and energy efficiency, improve their technological base, optimize the sale of goods, and adapt it to changes in market conditions. At the same time, company management systems are being restructured. Transformations are being carried out in the organizational, legal, property, financial, and production spheres—experience is gained, and employees' knowledge and management are expanded, the technological cycle is improved, and the system of interaction and integration with partners is debugged.

Structural renewal of industries is manifested in the form of a trend in the active formation of science-intensive integrated structures and the creation of knowledge-intensive and science-intensive clusters. The new integration architecture in the industrial and innovation sphere is due to the ongoing globalization of the economy, the accelerated development of Internet technologies, and the intensification of competition in the national and world markets.

The modern formation of integrated science-intensive structures is a way to overcome reorganization and reformation difficulties. By integrated science-intensive structures that form a single scientific and industrial complex, we understand a group of enterprises conducting scientific and industrial activities and sharing resources in the development, production and sale of industrial products or services based on the consolidation of all or part of assets and contractual relations, and for achieving common economic and non-economic goals.

At the mesoeconomic level, the process of establishing knowledge-intensive clusters is aimed at improving the efficiency of the companies that form it, which ensures the competitive position of the industry (region) and contributes to its innovative development. It should be borne in mind that innovations at this level are formed as a combination of the following important components:

- analysis of market opportunities in the industry (region)
- strategic planning
- scientific and design activities
- marketing research

When classifying the industry as knowledge-intensive, a costly approach is used. As a result, only the industry in which the ratio of R&D costs to product costs is higher than the world average for manufacturing in developed countries (about 4.5%) is referred to as knowledge-intensive.

The authors believe that in determining the industry as knowledge-intensive, one should take into account:

- the ratio of R&D costs incurred for the cost of products
- the ratio of the number of people employed in the field of science and development work to the number of people employed in the corresponding industry.

Therefore, the criterion by which the industry relates to knowledge-intensive should take into account not only the share of R&D costs in the production cost but also the share of those employed in the field of science and development work to those employed in a particular industry. At the same time, knowledge-intensive industries are those with a significant share of R&D costs. Consequently, the level of science intensity of the industry as a relative indicator is determined either using a costly or personnel approach. Knowledge-intensive industries occupy significant positions in the economic development of the Russian industry. At the same time, a knowledge-intensive enterprise is an enterprise that produces at least 50% of its products based on modern technologies. Despite the fact that a unified definition of a high-tech company, enshrined in a scientific approach, has not yet been formulated, it is believed that these are domestic enterprises that are focused on improving operational and economic efficiency due to relatively high innovative activity.

5 Conclusion

The innovative sphere of industrial production plays a special role in the structural changes in the industrial sector of the economy. The liquidation of inefficiently functioning companies, the restructuring of those operating on the basis of innovations, as well as the reduction of traditional types of production and an increase in the share of knowledge-intensive ones accelerate the formation of a progressive structure of industries and increases their competitiveness in the world market.

References

1. Belykh, L.P.: Enterprise Restructuring. Unity-Dana, Moscow, Russia (2015)
2. Bogatova, E.V.: Innovative Economy. Knorus, Moscow, Russia (2014)
3. Dudin, M.N., Reshetov, K.Y., Mysachenko, V.I., Mironova, N.N., Divnenko, O.V.: Green technology and renewable energy in the system of the steel industry in Europe. Int. J. Energy Econ. Policy **7**(2), 310–315 (2017)
4. Frolova, E.D., Strokovsky, L.E., Kanen, A., Jiang, J., Nikiforova, D.A.: Brix Phenomenon: From a Global Object to a Global Player. Ural Federal University Publishing House, Yekaterinburg, Russia (2011)
5. Milner, B.Z.: Strategic management: from art to scientificdiscipline. Economic Bulletin of the Southern Federal District **3**(38), 144–149 (2007)
6. Milner, B.Z.: Innovative Development: Economics, Intellectual Resources, Knowledge Management. Infra-M, Moscow, Russia (2009)
7. Milner, B.Z., Orlova, T.M.: Organization of the creation ofinnovations: horizontal communications and management. INFRA-M, Moscow, Russia (2013)

8. Reshetov, K.Y., Khoroshavina, N.S., Mysachenko, V.I., Komarov, V.Y., Timofeev, M.I.: State policy in the area of implementation of innovations in industrial production. J. Soc. Sci. Res. **53**, 271–276 (2018)

Intellectual Product Promotion: Marketing Evaluation and Communication Efficiency

Inga M. Sinyaeva and Olga N. Zhiltsova

Abstract The paper focuses on the analysis of the effectiveness of marketing promotion of an intellectual product on the basis of foreign and domestic research. A low level of contribution by Russia to the global innovation market is explained by the global crisis, economic sanctions, political instability, and drawbacks tax legislation. The authors provide recommendations to improve the effectiveness of marketing and promote intellectual products. Their analysis reveals the priorities in the field of marketing, as well as the dynamics of the main indicators of marketing communications (advertising technologies and digital marketing tools), relying on the Russian companies as an example. Also, the authors share their vision on the sustainable promotion of an intellectual product marketing as a result of creating a commercial system of innovative technologies, flexible use of advertising technologies, and digital promotion tools. More than that, the paper offers a systematic approach to the innovation policy of Russian companies, focusing on the creation of a commercial system for intellectual products. The practical use of marketing models to promote intellectual product and to solve the problems of commercialization in the main link of the national economy is also described in the paper.

Keywords Intellectual product · Innovation · Marketing · Digital · Model · Advertising · System · Structure · Digital economy

1 Introduction

We are all witnesses to the practical use of artificial intelligence, chatbots, and a variety of robots in everyday life, including in medicine, transport, at sea, and on land. It is no accident that in order No. 1632-r (July 28, 2017), the Government of the

I. M. Sinyaeva · O. N. Zhiltsova (✉)
Financial University Under the Government of the Russian Federation, Moscow, Russia
e-mail: 10olga05@gmail.com

I. M. Sinyaeva
e-mail: i.570@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_29

Russian Federation approved the program of the Digital Economy of Russia [1]. The investments envisaged for the implementation of the federal program “Information Society 2018–2020” in accordance with the Federal Law No. 362-FZ were ₽ 131.8 billion for 2018, ₽ 109 billion for 2019, and ₽ 111 billion for 2020 [2].

Despite the unfavorable economic situation, innovation activity continues to develop in the world. In most countries, the research and development costs exceed those of previous years, and successful local innovation centers flourish. The INSEAD International Business School, Cornell University, and the World Intellectual Property Organization annually publish “The Global Innovation Index”, which evaluates all countries in the world in terms of their development. The experts evaluated 126 countries based on 80 different parameters—from the number of applications for intellectual property rights and created mobile applications to the amount of spending on education and the number of scientific and technical publications. For the eighth consecutive year, Switzerland ranks first. “The most successful countries with a high level of innovative development have found such a combination of political measures that allows them to maximize the return on investment in innovation in all sectors of the economy,” says the report.

Table 1 shows the leaders of the global innovation arena in 2018.

In 2018, Russia was 46th in the overall ranking, and 45th in 2017 [3].

The following scholars made a great contribution to the development of the theory of innovative marketing: D. Aaker, T. Ambler, D. Bell, E. Braert, Edward de Bono, D. Car, F. Kotler, T. Levitt, P. Drucker, P. Doyle, J.-J. Lambin, R. MacNeil, S. Minette, J. Pasmatier, R. Wright, D. Trout, D. Tapscott, F. Webster, G. Harding, P. Herbig, V. Ya. Gorfinkel, E. P. Golubkov, Y. N. Grick, A. P. Pankrukhin, Yu. N. Soloviev, O. U. Yuldashev, A. A. Engovatov, and others.

For the ongoing development of innovations, the generation of new ideas in the main link of the national economy, taking into account the needs of modern society, is extremely important. The speed of launching new products on the market is

Table 1 Top 10 countries in terms of innovation in 2018

No.	Country	GII index
1	Switzerland	68.40
2	Netherlands	63.30
3	Sweden	63.10
4	United Kingdom	60.10
5	Singapore	59.80
6	USA	59.80
7	Finland	59.60
8	Denmark	58.40
9	Germany	58.00
10	Ireland	57.20

Source Analytical Center under the Government of the Russian Federation [2] important as well. It becomes possible to speed up promoting an intellectual product on the market, taking into account a systematic approach to disclosing the marketing strategy for innovation policy; the principles and objectives of achieving the goal; creating a commercial system of innovative marketing; and forming a marketing model for promoting an intellectual product. The development cycle of any startup is based on the research cycle "research—development—distribution (marketing)—commercialization." The target function of innovative marketing is to anticipate the needs of society by developing innovations to improve quality of life. The organization of innovative marketing is based on the use of the following principles: creating the intellectual potential of the company; development of key competencies of the organization (knowledge, skills, and abilities); and a systematic approach to the use of integrated marketing communications, social orientation and economic feasibility of partnerships.

When developing a startup of an intellectual product, it is necessary to create an integrated commercial system that takes into account the diverse elements directly affecting commercialization and the maximum satisfaction of society's demand for the new product. The commercial system integrates all the stages of the innovation process from the search, research and development, laboratory (bench) tests of the head sample of the new product, test marketing before mass industrial production, and launching the new product on the market, taking into account potential consumer demand.

2 Materials and Methods

It is known that, despite globalization, all phenomena in the world are systematized in the form of interconnected supersystems, systems, subsystems, species, subspecies, and elements. The term "business hyper-connectivity" is defined as the set of elements that are in regular relationships, being connected with each other and forming a certain integrity or unity in the business sphere under the influence of such super-systems as economics, nature, society, and the market. The concept of "hyperconnection" was introduced at the beginning of the twenty-first century by Canadian sociologists A. Quan-Haase and B. Wellman as a mechanism for the interaction of communication systems in the world—"man—man" and "man—machine" in the framework of a network organization [4]. The scheme of the innovation marketing system is shown in Fig. 1.

When forming a commercial system, one must remember the constant influence of such super-systems as nature, society, the economy, and the market.

The main tasks of creating an IMS model are: developing a philosophy of market participation using an integrated approach to assessing market environment factors; the justification of the target sales segment, taking into account the demand for a new product, the solvency of consumers, and the level of competition; the use of trial marketing; obtaining the intended income from the commercialization of a new product.

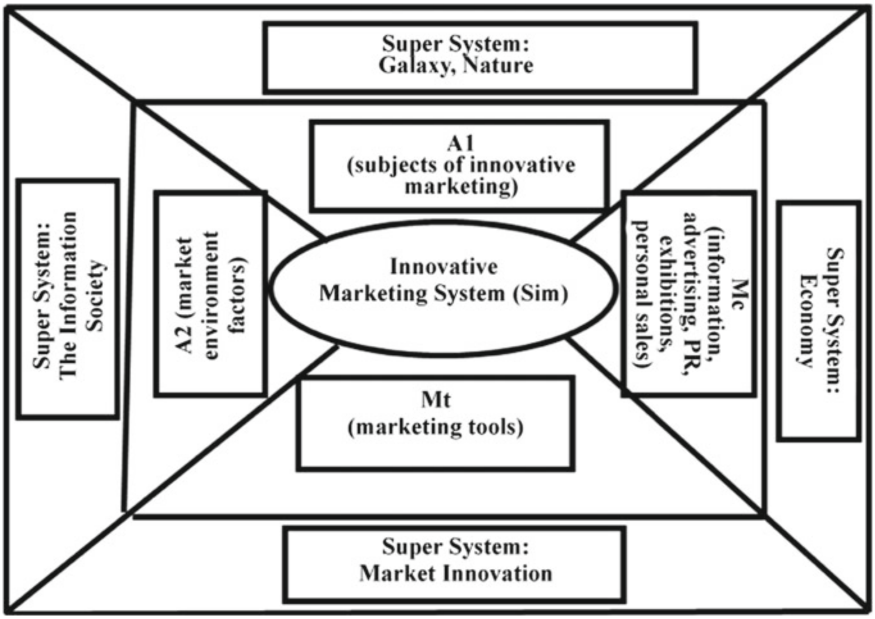

Fig. 1 The model of an innovative marketing system (IMS). *Source* Developed by the authors

The structure (ISM), in general, can be represented as a functional dependence on the elements:

$$ISM = f(A1, A2, Ip, Mc, Mt).$$

In particular, A1—the initial components of the system (elements, factors, market participants, suppliers, consumers, intermediaries); A2—the combination of constituent elements in space and time (complex, totality, factors of the market environment that carry out the invasion in all aspects of human life).

Already at the beginning of the twenty-first century, with the advent of the sphere of 3-D printing (production of donor organs), the mass introduction of robotics changed and improved the quality of production processes in medicine, the quality of human life, and our everyday routines.

Ip—an intellectual product (from the Latin 'Intellectus'—mind) is the result of spiritual, mental, and intellectual activities as a process of material embodiment in the form of scientific inventions, discoveries, startups, and innovative technologies designed to meet the reasonable needs of society.

Mc—the marketing communications: a holistic set of diverse forms and methods of transmitting information to the target audience about new products and services, with the practical use of advertising technologies, personal sales, direct marketing, and public relations. According to F. Kotler, any organization develops its concept of integrated marketing communications in order to “develop a consistent and convincing view of the company and its products” [5].

Mt—the marketing tools that integrate primarily elements of digital promotion of an intellectual product in its composition. In modern conditions, in the process of promoting an intellectual product, the following tools of digital promotion online and offline are used as much as possible: SEO optimization, contextual advertising, banner advertising, targeting, viral advertising, push- and pop-up windows, native advertising, mobile communications, media, radio, and TV.

It should be noted that the investors in the development of innovative technologies (e.g., Big Data, Internet of Things, mobile devices, cloud technologies, robotics and drones, artificial intelligence, smart clothes, social networks) are mainly the representatives of large businesses, primarily from oil companies. The forecast of the investments in innovative business is shown in Fig. 2 as an example of which technologies oil companies are already investing in.

The world practice of entrepreneurship confirms that the basis of innovative business is the strategy of holistic marketing, which development was influenced by the famous scholars F. Kotler, K. Keller, R. Coase, J.-J. Lambin, D. North, and M. Olson. The philosophy of holistic marketing provides, in addition to a systematic approach to carefully taking into account the interests of consumers, maximizing their satisfaction, taking into account spiritual needs, and a new style of consumption. It is necessary to regularly conduct a comprehensive assessment of the contribution of each performer to the development processes and commercialization of new items, based on the feedback analysis with target consumer audiences.

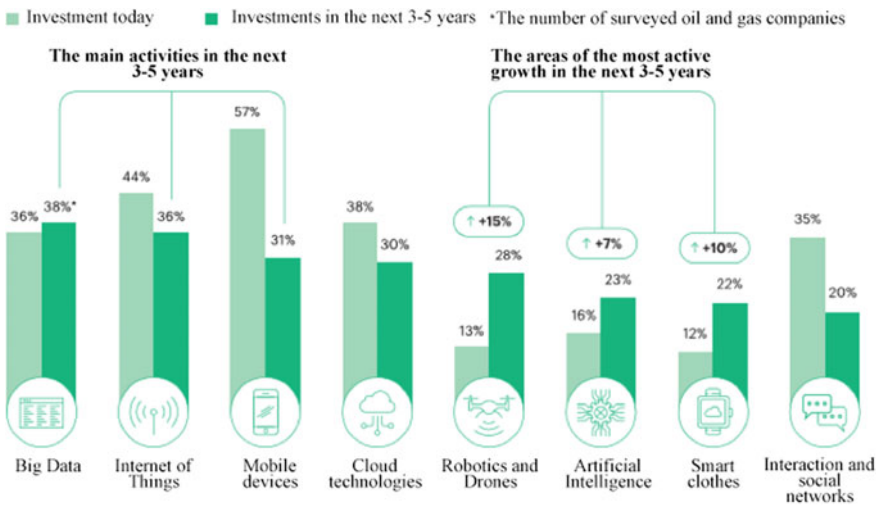

Fig. 2 Popular innovative technology in the next five years. *Source* RBC [6]

3 Results

A special place in holistic marketing is given to modern behavioral concepts. Jean-Jacques Lambin interprets relationship marketing as "a system that creates the necessary conditions for establishing long-term and constructive relationships with customers, which in the long run leads to high commercial results" [7].

The marketing model for promoting innovative technologies is shown in Fig. 3.

The marketing promotion of innovative technologies is a holistic unity of interrelated elements, functioning as a dynamic mechanism for the successful promotion

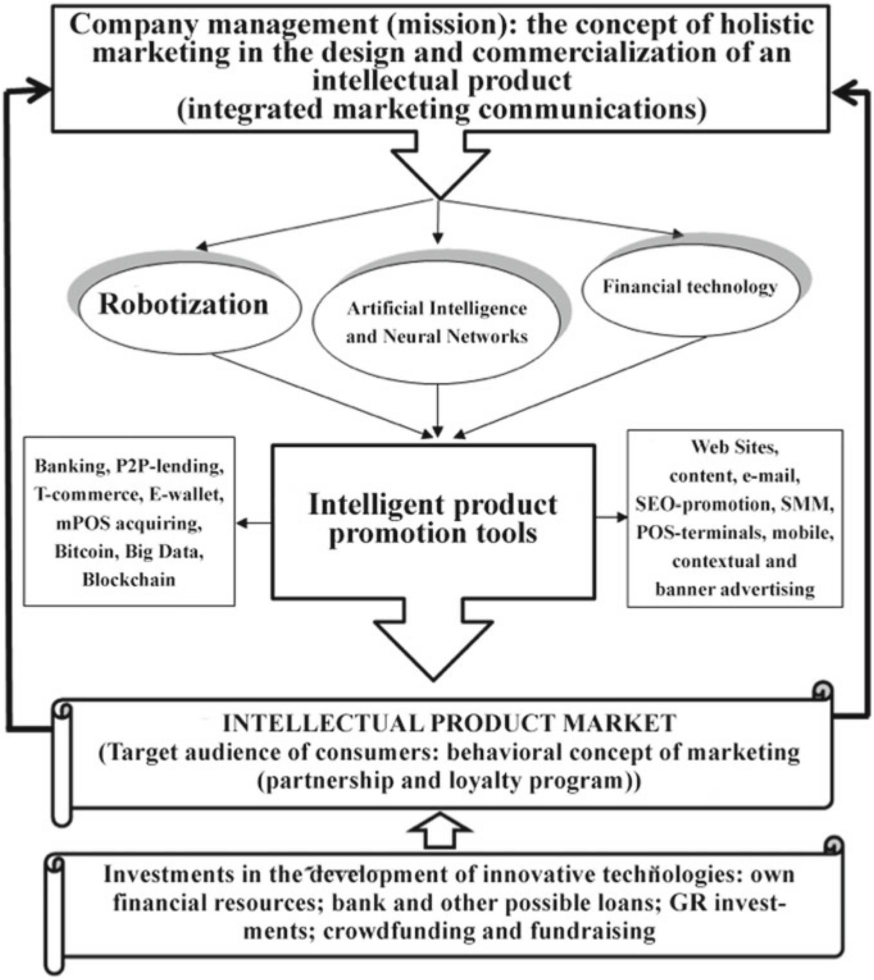

Fig. 3 The model of marketing promotion of innovative technologies. *Source* Developed by the authors

of new products. It must take into account the interests of consumers, service and social responsibility for the results of marketing activities. The intellectual product is the material basis of innovative technologies in the field of banking (FinTech), the production of robots, and the development of an intellectual product.

The FinTech technologies provide an opportunity to create a short way to introduce new projects, reduce the time of promotion to the market, and improve the efficiency of business processes.

The modern financial technologies are as follows:

P2P (person-to-person) lending—a method of financial transactions in which the loan of money is carried out without the participation of banks, and the lender is an individual. The first companies that determined the development of this market were British Zopa, American Prosper and Lending Club. In Russia, there are two services, Vdolg.ru and the credit exchange based on the WebMoney service.

E-wallet—an electronic wallet that allows paying for goods or services over the Internet. The popular services are PayPal, the largest debit electronic payment system (a division of eBay since October 2002), and Yandex. Money (which allows payment by electronic money, cash, and bank cards). Electronic payments can also be carried out through mobile applications for Android, iOS, Windows Phone, Windows 8, and Windows RT (payment currency—Russian ruble).

Bitcoin—a peer-to-peer payment system having the same unit for accounting transactions. In other words, Bitcoin is an electronic cryptocurrency as a replacement for cash when buying goods and services over the internet.

mPOS acquiring—mobile POS-terminals (Mobile Point of Sale). International payment systems (VISA, MasterCard) establish the rules of operations for banks.

T-commerce—"Tablet Commerce", which replaces m-commerce, which at one time replaced e-commerce. This model assumes that users actively communicate in real time, exchange personal experiences with each other and receive targeted offers of goods and services at a walking distance.
M-wallets (mobile banking) presents an opportunity to implement financial services through mobile and online platforms;
Big Data involves analyzing and storing huge amounts of data. The marketing technology of Big Data includes the analysis of customer behavior to improve the quality of services, helps individuals to manage their own finances, and aims to create additional systems (trading systems, electronic document management systems, and software systems for data modeling) for successful digital promotion of goods and services.

Blockchain—a specialized technology that allows the storage of data about operations and operates with only the resources of the participants of the system. In other words, a blockchain is a continuous sequential chain of blocks containing information built according to certain rules. Most often, the copies of blockchains are stored on many different computers independently of each other. The marketing of blockchain technology allowed the insurance industry to create cyber policies with a guarantee of cybersecurity, a multiparametric system of individual freight billing that uses a scoring model and many other programs.

An important contribution to the development of neural networks was made by F. Rosenblatt. In 1958, he developed a perceptron system that simulated the processes of the brain. Fifty years later, in 2007, the English scientist G. Hinton proposed the mechanism of multilayer neural networks, which are now successfully used in the work of unmanned vehicles.

The target function of the robot is to replace people whose work is associated with increased risks. The main types of robots include unmanned passenger transport, robots for commercial spaces, robot-interlocutors (assistants), logistics robots and unmanned cargo transport, collaborative robots, industrial exoskeletons, and robots for agriculture. The most common functions of robots are: placing objects in space (take an object and drag it to another place); packaging and palletizing (packaging in shrink film and placing on pallets); using programming, solving contact problems (the necessary algorithm) in the welding process; digitally checking the quality of parts (CAD), etc.

The leader in the global market for robots is China, which annually increases the number of robots at its enterprises by 20%, and by 2020, another 650 thousand units of robotic mechanisms will be introduced on the continental territory of the country.

The Russian market of industrial robotics is small and amounted to about ₽ 10 billion in 2018. There are 10 domestic robot manufacturers. Domestic companies ExoAtlet and CyberTech Labs have already entered the world market and are successfully competing with foreign robot manufacturers.

In 2018, Russian automotive companies introduced 103,300 robots (6% more than a year earlier). But it is automobile companies that most often produce and acquire robots—they provide 35% of all sales (Report of the International Federation of Robotics (IFR), 2018) [8].

Obviously, the big unresolved problem with the marketing development of innovative technology promotion is a limited investment, despite the support of the state, the institutions of entrepreneurship, and the public. The activation of modern forms of crowdfunding and fundraising should be noted.

Crowdfunding is a technology for the implementation of social investments as the investments of the population in various social business projects using the Internet. According to J. Howe, crowdfunding covers a diverse group of approaches united by one common feature: they are all based on the participation of many people. J. Howe notes: “Crowdfunding does not depend on knowledge, creative energy, and the views of wide circles of the population. This is about raising their dollars, pounds, and pesos” [9]. The most famous crowdfunding platform in Russia is planeta.ru.

Fundraising presents a donation process to support socially important events. Fundraising has been actively developing in Russia since the 1990s, during the formation of nonprofit organizations whose activities are not aimed at making a profit but at solving socially important problems. Fundraising is a fairly new phenomenon in the economic space of Russia. Fundraising refers to activities to attract resources. It involves the search for resources, among which financial resources occupy an important place but not the only place. In general, the following types of resources can be distinguished: finance; material (machinery, equipment); informational; and human (the work of volunteers).

Fundraising can be "internal" and "external." In the first case, the development and implementation of a strategy for the search of financing are carried out independently by the NPOs. In the second case, this is one of the areas of consulting activity, when the search for financing is carried out by attracting professional fundraising consultants. Independent experts and specialized fundraising firms can play this role. As an example, we can cite the fundraising work of the Siemens company: a competition for high school students. The competition was developed as part of the implementation of Siemens' social programs and is aimed at involving young people in activities to improve the quality of life and create a favorable living environment for the residents of Russia. The competition of scientific and innovative projects is a national project for implementation by Siemens in all federal districts of Russia. The cost estimates for the high school competition are presented in Table 2.

One of the most well-known resources to support fundraisers is the Fund for the Development and Support of Philanthropy (https://www.cafrussia.ru/).

Table 2 The cost estimate for the siemens competition

Budget item	Cost (P)
The development of the creative concept	149,253.73
Prize pool	2,842,574.53
Advertising campaign	1,283,582.09
The work of the expert councils	1,229,660.23
Ceremonies (7 Regional + 1 Federal)	1,168,438.93
The work with schools	519,595.30
The production of the final film about the competition	105,895.52
Logistics	629,648.75
The work of the call center (sending e-mails)	249,002.99
The coordination of the project (regional agencies)	3,276,100.75
The production of the final film about the competition	248,879.10
Agency services	3,346,268.66
Total	15,048,900.57

Source Siemens official website. Retrieve from https://new.siemens.com/ru/ru.html

4 Discussion

We are all witnesses of the implementation of modern breakthrough technologies in robotization, artificial intelligence, and neural networks. These all contribute to the creation of comfortable conditions for human life. Microsoft, Amazon, Baidu, and Google were the pioneers in the implementation of artificial intelligence in the global arena. It is clear that these are precisely the technologies that will completely replace human labor in the short term.

5 Conclusion

In conclusion, it is important to note that the practical use of the commercial system of innovative marketing, the marketing model for promoting innovative technologies, promotes the use of a systematic approach not only for an intellectual product, but also for effective communication with investors, representatives of the media, and the business community. Most importantly, using this system could facilitate successful positioning in the eyes of consumers and attract profitable investments, which, in general, would create a positive reputation for an intellectual startup product.

Acknowledgment The authors are very grateful to their colleagues, editors, and publishers for their joint scientific work and research. The article was published according to the results of the research "'Made in Russia'—A toolkit for supporting goods manufactured in Russia" (2019).

References

1. Government of the Russian Federation: Order on the approval of the program "Digital Economy of the Russian Federation" (July 28, 2017 No. 1632). Retrieved from https://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf (2017)
2. Analytical Center under the Government of the Russian Federation: News overview 12.01.2018. Digital economy 2024. Retrieved from https://ac.gov.ru/files/attachment/15711.pdf/ (2018)
3. Global Innovation Index (GII): Ranking of countries by innovation level. Retrieved from https://nonews.co/directory/lists/countries/global-innovation-index/ (n.d.)
4. Osterwalder, A., Pigne, I.: Building Business Models: Handbook of Strategist and Innovator. Alpina Publisher, Moscow, Russia (2013)
5. Kotler, F., Armstrong, G.: Marketing Basics, 5th European ed. Dialectica Publishing House, Moscow, Russia
6. RBC: Industry 4.0: How Russia cannot miss the technological revolution. Retrieved from https://digital-russia.rbc.ru/article-page_2.html (n.d.)
7. Lambin, J.J.: Market-Driven Management: Strategic and Operational Marketing. Palgrave MacMillan, New York (2007)
8. Krasilnikova, J.: The report of the international federation of robotics (IFR) 2017. Retrieved from https://hightech.fm/2017/09/28/ift_robotics_report/ (2018)
9. Howe, J.: Crowdsourcing: Collective Mind as a Tool for Business Development. Alpina Publisher, Moscow, Russia (2012)

Priority Areas for Improving the Effectiveness of an Information and Consulting Service

Vladimir N. Arefiev

Abstract Improving the effectiveness of information and consulting support for agricultural producers is an urgent problem from a scientific point of view. It also acquires prior economic importance in connection with the urgent need to transfer agricultural production to an innovative development path. With the beginning of market transformations, questions of organizing an information and consulting service (ICS) began to receive increased attention. In order to ensure the effective operation of the ICS, it is necessary to develop proposals to improve the efficiency of its activities. The authors analyze the tasks, working methods, the role and place of ICS in the innovative development of the agro-industrial complex. The main problems of the service activity are identified. They include the disunity of the system, organizational problems, fragmented information and methodological support, personnel problems, insufficient material and technical support. The ways of their solution are proposed.

Keywords Innovations · Agro-industrial complex · Information and advisory service

1 Introduction

In recent years, agriculture has become one of the main areas of the socio-economic development of the country. Significant funds are invested in agriculture; a whole range of measures, aimed at supporting an important sector of the Russian economy, is being implemented [6].

The efficiency of agricultural production and the sustainability of agricultural development depend on a large extent on the use of the achievements of scientific and technological progress [5]. An important role is given to agricultural counseling among the main directions of state support for the development of agriculture and solving the problems of the industry modernization.

V. N. Arefiev (✉)
Russian State Agrarian Correspondence University, Balashikha, Russia
e-mail: kay1958@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_30

In modern conditions, the rise of agriculture is impossible without the activation of innovation, which is the main factor in the system of factors that ensure the development and increase the efficiency of production in the market economy [2, 4].

The diffusion of innovations allows the achievement of the maximum result from the introduction of innovation and get the maximum effect both for the innovative enterprise and for the national economy as a whole, and this is considered to be the main activity direction of the information and consulting service.

The main goal of the agricultural consultation system is innovative modernization and increasing the efficiency of agricultural production based on the development of scientific and technological progress, improving the forms and methods of consulting activities. The basis for the development of the agricultural advisory system is the need for advisory services, stimulating the development of innovations.

2 Materials and Methods

The theoretical and methodological basis of the study was the works of scholars and leading experts on the development of agricultural counseling systems; the normative and scientific literature; the publications in periodicals on the considered subject; the materials of agricultural management bodies and scientific and practical conferences. In the process of work, such traditional research methods as abstract-logical, expert evaluations, questionnaires were used.

We have distinguished three main areas of work of ICS on the introduction of innovations in the activities of agricultural enterprises:

1. the innovations in the field of human capital—training of specialists able to exploit new equipment and technologies, improving their skills, retraining, mastery of metacompetencies, allowing to adapt professional activities in the conditions of market competition and a dynamically changing context, focus on the design of the improving changes, and improving the manufacturability of professional activities;
2. the innovations in the field of biological factors—the promotion of innovations that increase animal productivity, crop yields, and the fertility of agricultural land;
3. the innovations in the field of anthropogenic factors—improving the technical and technological potential of an agricultural enterprise.

The innovative infrastructure of the agro-industrial complex is geographically distributed, diverse, multi-level, and possesses a high specialization. The approbation and verification of the obtained samples are carried out by scientific institutions, special state institutions, and organizations [8]. The reproduction of innovations in agriculture is carried out by seed-growing farms (growing elite and reproductive seeds of new varieties and hybrids of agricultural crops); pedigree plants (breeding of pure pedigree animal lines); machine-building enterprises (serial production of new equipment); and biological factories (production of vaccines, etc.) [9]. The objects of innovation and consulting infrastructure of the agro-industrial complex are very diverse in organizational and legal forms, types of ownership, sizes, goals and objectives, types of activities, and sources of financing [7]. In addition to the aforementioned, they include educational-experimental, educational-production, basic farms, technology parks, technopolises, science cities, technological platforms, agricultural university complexes, small innovative enterprises, clusters, educational institutions, basic departments, business incubators, coworking centers, and others.

3 Results

The conducted sociological research showed that the introduction and market development of innovations is constrained by a number of factors, among which the most important are the low solvency of farms and the lack of reliable and complete information about the latest domestic scientific developments in the field of agriculture.

Despite the achievements in developing and increasing the impact of the agricultural consulting service on agro-industrial production, there is a request to diversify the goals and objectives of the service, improve working methods, and bring the content of innovative ICS activities in line with the national goals of the Russian economy on the transition of agribusiness to the path of innovative development.

The main tasks that the information and consulting service should solve, in our opinion, should be the following:

- the dissemination of information on modern knowledge and achievements of STP in agro-industrial production;
- the formation and accumulation of information resources and data banks demanded by commodity producers [1, 3];
- the advisement of the producers on the organization, economy, production technology, and sales;
- the introduction of innovations that reduce production costs throughout the integrated chain of "development-replication-adoption-sales";
- the training of qualified personnel who are capable of organizing efficient production and sales of products in a market environment;
- helping in the analysis and evaluation of the results of production and economic activities of the producers.

The trend analysis of the basic type of activity of consultants on the organization of practical agricultural counseling in the field indicates a number of serious systemic problems:

- the disunity of the system. In the presence of a diverse and extensive innovation and consulting infrastructure, its integration processes are poorly developed. The implementation units in universities and research institutes do not have any significant impact on the innovation and consulting support of the agro-industrial complex. The implementation structures of manufacturers are virtually absent, and their activities are reduced to trade and marketing.

- the organizational problems. There exists different organizational subordination of ICS organizations, different sources of funding and levels of ownership, and differences in strategic approaches to the formation and activities of ICS organizations.
- the fragmentary information and methodological support. The Federal center for agricultural consulting and retraining of agricultural personnel could not become an integrating body of the ICS system. There is no single public information base. Existing electronic databases are not integrated, they duplicate each other, and they are formed randomly. There is no coordination and planning in the development of methodological support for consulting activities and the evaluation of the quality of development. This creates a lack of efficiency in the system, incomplete compliance with the requirements of the innovation-oriented sector of the agricultural economy, and a delay in the reaction of the system to new market needs and demands of agricultural producers.
- personnel problem. Many consultants do not have sufficient practical work experience in agriculture and, accordingly, cannot conduct the necessary level of consultation, adaptation, and implementation of high-tech innovations. When considering candidates for consultant positions, successful experience of practical work in the specialty should be mandatory. It is necessary for working consultants to expand and make mandatory training in the workplace with the final certification. In fact, there is no work on the formation and training of a personnel reserve in order to rejuvenate the composition of consultants and create conditions for consolidating promising consultants. The representatives of innovation developers are not sufficiently involved in the processes of consulting and implementation activities.
- inadequate logistical support. The ICS organizations do not have enough office equipment, proper means of operational communication, or necessary licensed software. The demonstration sites are created haphazardly, and training places are not equipped.

4 Discussion

In order to achieve a sustainable positive trend, we propose to improve the work of ICS in the following areas:

- strengthening regional agricultural advisory centers and expanding the municipal agricultural advisory network;
- addressing the development of the demonstration base, the creation of collective use centers, exhibition venues of leading enterprises, innovation and implementation centers, agricultural technopolises with the provision of educational, informational, consulting, and demonstration services; centralized conclusion of

contracts with manufacturers and distributors for the supply of domestic and foreign machinery and equipment for educational, advertising, service purposes (including new models and designs (concepts);

- increasing the number of consultants, primarily due to the involvement of specialists; training of consultants;
- expanding the scope of consulting activities;
- raising the awareness of agricultural producers and the rural population about the potential of consultants;
- increasing the business credibility of agricultural advisory centers.

The basic principles on which the functioning of ICS is based should be:

1. Leadership and financial support from the state, local authorities, and the business community. At the federal level, not only the Ministry of Agriculture of Russia, but also the Ministry of Industry and Trade, the Ministry of Economic Development, the Ministry of Natural Resources, the Ministry of Education and Science, and others should be involved in accordance with the priorities of state programs related to the agricultural sector and socio-economic development. At the sub-federal level, in accordance with the development programs of the agro-industrial complex and rural territories. At the municipal level, in accordance with local social and economic development programs. The allocation of grants from manufacturers to study the market, demonstrate the benefits of products in a production environment, create service-training-marketing centers based on innovators, etc. The creation of commercial innovation transfer centers with the participation of ICS, agribusiness innovation development funds;
2. Attracting highly qualified specialists to work in information and consulting centers in one or several branches of agricultural knowledge. They must know research, training, and innovation methods;
3. The influence of agricultural producers in determining the strategy and planning of the activities of agricultural consulting centers through participation in the work of colleges, advisory committees, supervisory boards, expert councils, and other governing and advisory bodies;
4. The openness of the system for promoting agricultural knowledge, the presence of feedback providing intensive regular and mutual exchange between specialists of the implementation service, researchers, teachers, and agricultural producers; the creation of a self-regulatory organization of agricultural consultation and the development of common standards for consulting activities;
5. The use of a variety of counseling methods (direct individual and group contacts of agricultural producers with employees of information and consulting services, the media), the widespread use of demonstrations of new technologies and technical solutions directly in farms and enterprises.

5 Conclusion

To increase the effectiveness of ICS, manageability, and the influence of the state on the agricultural counseling service, it is proposed:

1. To increase the availability of ICS; for this, it is necessary:

    (a) to create the industry information, consulting, and training platform *Agrodistant*—a remote access system for consulting and participating in training events, including an integrated digital library of normative, educational, methodological, reference, and consulting materials; to create digital library systems and databases for industries and climate zones with aggregation on an industry platform;
    (b) to increase the number of scientific and practical conferences on pressing problems of the agro-industrial complex with demonstration displays;
    (c) to expand cooperation with industry unions, associations, and subjects of Russia;
    (d) to intensify publishing and exhibition-propaganda activities radically.

2. To Improve the Quality of Advisory Services; for This, It is Necessary:

    (a) to create a research laboratory for monitoring and ICS methods on the basis of the parent organization of agricultural consulting with funding from the federal budget;
    (b) to include the development of the theory and practical recommendations for consulting support of the agricultural sector in the research plan of the Ministry of Agriculture of Russia with financing from the federal budget;
    (c) to develop communications and study the domestic and foreign experience with ICS.

Russia's modern innovation policy in the field of agribusiness should be aimed at supporting and creating favorable conditions for the development and improvement of ICS, an important element in increasing the competitiveness of domestic agricultural products, growing the agricultural sector of the economy, and ensuring the economic and food security of the state.

References

1. Alt, V.V.: Savchenko, O.F.: Information resources—the technological basis of the innovative development of agriculture. Sib. Bull. Agric. Sci. 10:102–111 (2009)
2. Bogoviz, A.V., Bugai, Y.A., Minenko, A.V.: Economic analysis of effectiveness of the existing tools of state support for entrepreneurship in the AIC in the digital economy. Lect. Notes Netw. Syst. **57**, 789–794 (2019)
3. Gerasimov, A.A.: Information support of state land control: concept, content, problems and suggestions for improvement. Agrar. Russ. **6**(1), 51–56 (2011)

4. Imangalieva, A.K., Bonichev, A.L.: The development of information support for the regional grain market. Business. Education. Law **2**(15), 97–100 (2011)
5. Lubkov, A.N.: Prospects for the development of agricultural counseling in Russia. Econ. Agric. Process. Enterp. **12**, 1–5 (2010)
6. Lutfullin, Yu.R., Sirazetdinov, I.S.: The formation and evaluation of the effectiveness of the information and consulting service in the regional agro-industrial complex. RegNal Econ: Theory Pract **42**(225), 19–23 (2011)
7. Makovetsky, V., Priemko, V.: Monitoring of information support for agricultural producers. AIC: Econ, Manag **1**, 71–75 (2011)
8. Mukhamedzhanov, E.R.: Consulting support for the innovative development of the agro-industrial complex of Russia. Oil, Gas, Bus **1**, 66–68 (2011)
9. Nechaev, V., Polutina, T., Zemlyanykh, E.: Scientific information cluster in the agricultural complex of the Krasnodar Territory. AIC: Econ., Manag. **10**, 23–29 (2010)

Strategic Aspects of Digitalization of Macro and Mesoscale Economy as a Prerequisite for Innovative Development

Veronika V. Chernykh, Alevtina P. Suvorova, and Valeriy L. Chernykh

Abstract The paper focuses on the study of the strategic aspects of the digital economy development as an important prerequisite for innovative development at both the macrolevel and mesolevel. In the research process, systemic, process, integration, modernization, and innovative approaches to the issue of economic digitalization were highlighted. The main goal of the paper is to assess the strategic opportunities for the development of the digital economy at the macrolevel and develop recommendations for their implementation taking into account the current mesoscale conjuncture. The authors evaluate the achievement of the strategic goals of digitalization of the macro/mesoscale economies in order to implement the human potential, with the allocation of three groups of indices characterizing the information, scientific, and organizational potential. In order to solve the research problems, general scientific methods were used, including systematization and classification methods, system and situational analysis, factor and correlation-regression analysis, and statistical observations. The data coming from the Rosstat and HSE was monitored using a system of indicators with a reference period of one year. When implementing digital technologies at the macro and mesolevels, the authors consider the possibility of expanding the range of solutions to achieve the goals of sustainable and innovative development.

Keywords Digital economy · Digitalization · Macro- and meso-economic levels · Sustainable development · Innovative development

V. V. Chernykh (✉) · A. P. Suvorova · V. L. Chernykh
Volga State University of Technology, Yoshkar-Ola, Russia
e-mail: veronika_chernyh@mail.ru

A. P. Suvorova
e-mail: saprof@mail.ru

V. L. Chernykh
e-mail: ChernykhVL@volgatech.net

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_31

1 Introduction

The meso-economic level can be considered as a platform for the introduction and development of digital technologies. Digitalization of the economy will make it possible to implement a scenario of a sustainable economy with a gradual transition to innovative development. As part of the development of strategic aspects at the macro level, the digitalization process of various sectors and fields of activity of the meso-economic level should be taken into account, which will accelerate the implementation and development of innovative projects.

Not all Russian regions have the same opportunities for innovation, including the development of the digital economy. The opportunities for its development are mainly determined by the presence of scientific and innovative potential, as well as an intellectual resource. The scale and types of activities of manufacturing enterprises, the development trends in the economies of industries and regions in which digitalization takes place, are determined by the current conditions of the micro- and mesoscale markets [7].

One of the important criteria is Russia's place in the international community in the development of the information society. According to the criteria of the strategy adopted in 2008, by 2015, the Russian Federation should be among the 20 leading countries of the world [8]. The actual place of Russia in international ratings compiled by experts from the Higher School of Economics is as follows: in 2010, Russia ranked 46th; in 2011, 38th; in 2012, 41st; in 2013–2015, 42nd; in 2016, 43rd; and in 2017, 45th place [1].

The government has developed a new document that spells out the main tenets of the development of the digital economy at present: "The strategy for the development of the information society in the Russian Federation for 2017–2030" (May 9, 2017 No. 203). The new strategy for the development of the information society is designed to help to achieve national interests: the development of human potential and ensuring the safety of citizens and the state [2].

The main purpose of this paper is to assess the current situation and the formation of strategic opportunities for the development of the digital economy at the macro level, taking into account the sectoral and territorial principles of the mesoscale.

The objectives of this study are the development and testing of an algorithm for monitoring factors, and indicators of the development of the digital economy within the mesoeconomic level. Testing will be carried out at the macro- (for example, the Russian Federation) and mesoeconomic level (for example, the Republic of Mari El and the Kirov region).

2 Materials and Methods

A comprehensive study of the proposed approaches of the essence and features of the digital economy's development allows us to judge the digitalization's impact on the market system. As one of the fundamental foundations of economic theory, it is transformed under the revolutionary influence of information and communication technologies (hereinafter ICT).

Modern scholars have identified various approaches to the development of the digital economy. From the perspective of modern economic science, they distinguish a systematic approach to the issue of digitalization, presented by Solozhentsev [12] and Schwab [11]; the process approach proposed by Necheuhina et al. [9]. K. V. Yakushenko and A. V. Shimanskaya consider the information transformation of economic systems from the perspective of integration [15]. V. I. Grushenko justifies the digitalization of the economy as a stage of evolutionary development [6]. The approach to digitalization from the perspective of modernization development is substantiated in the works of Prudsky and Volodina [10, 14]. Table 1 presents a comparative analysis of approaches to the essence and features of the digital economy's development.

It is interesting to consider the selected approaches in terms of sustainable and innovative development scenarios. Many aspects of digital economy development at the meso-economic level in the context of the world economy globalization and the modern institutional environment remain controversial.

3 Results

In order to assess the Russian Federation's digitalization at the macro level, a comparative analysis of the target criteria is necessary, according to the "Strategy for the Development of the Information Society," adopted in 2008, with statistical data at the time of implementation. The absence of data on a number of parameters in the official federal and regional statistics imposes a restriction on the completeness of the information.

At present, it seems difficult to accurately assess the existence of conditions for the formation of a knowledge society in the Russian Federation due to the lack of statistical data. Statistical collections are characterized by partial availability of data on digitalization of enterprises in the absence of information on digitalization of the population.

Subsequent analysis and interpretation of the results are presented in the framework of the selected nine indicators in the form of indices (Table 2).

The indices shown in Table 3 are analogues of the target criteria. Their values were selected for statistical collections.

Table 4 presents the results of correlation and regression analysis to assess the tightness of the relationship between the indicators in question and the values of GDP (federal level) and GRP (regional level) (Table 4).

Most parameters have strong relationships between the obtained values. The parameters with the values of less than 0.5 are characterized by a weak level of communication. They are the index of differentiation of constituent entities of the Russian Federation by ICT (Index 3), the index of computerization of households

Table 1 The approaches of Russian and foreign authors to the development of the digital economy

The author of the approach	The essence of the approach, its advantages and disadvantages
Systematic approach	
[12]	The author presents theories and technologies of digital control of the state and economy. The digital economy is seen as part of a holistic system of economic relations
[11]	The author emphasizes the transforming impact of digital technology on the industry, the positive and negative effects of the digital revolution on society
Process approach	
[9]	The authors consider the digitalization of the economy from the point of view of the production process in a transformation of the market environment. The authors propose the introduction of controlling as a mechanism for the development of the digital economy. There is no analysis of the negative effects of digitalization
Integration approach	
[15]	The authors examine the digital transformation of economic management information support in terms of integration, using the example of the EAEU member countries. Not considered are the aspects of increasing labor productivity
Innovative approach	
[6]	Innovations in the field of information technology are presented by the author in terms of economic transformation. The author's concept is proposed, which consists in interpreting changes in consumer values as a result of information evolution
Modernization approach	
[10]	Digitalization is considered by the author from the point of view of integration of technical production systems within the framework of the fourth industrial revolution
[14]	Digitalization is presented by the author in terms of a modernization approach, emphasizing the advantages of digital, industrial platforms

Source Compiled by the authors

(Index 4), and the index of internal costs of the ICT sector for research, which are excluded when analyzing the parameters of the mesoscale (Index 5). Due to a lack of information, the index on patents of the Russian Federation in the field of ICT is not included in a number of analyzed parameters of the mesoeconomic level (Index 6).

According to the "potential" parameter, three groups of indices are distinguished—information potential (I1, I4, I7); scientific potential (I2, I5, I6); and organizational potential (I3, I8, I9). The data presented in Table 5 make it possible to evaluate digitalization at the macro-level (Table 5).

Table 2 The correspondence of indicators and indices of the digital economy

Indicator	No
The percentage of the population—active Internet users, %	Index 1
The percentage of investments in ICT equipment in total ICT costs, %	Index 2
The percentage of differentiation of the constituent entities of the Russian Federation in terms of ICT, units	Index 3
The percentage of households with a personal computer, %	Index 4
The percentage of internal costs for research in the ICT sector, %	Index 5
The percentage of Russia in the number of patents in the field of ICT, %	Index 6
The percentage of the population that used the Internet to receive state and municipal services, %	Index 7
The percentage are of electronic interdepartmental workflow, %	Index 8
The percentage of placed government orders using electronic trading platforms (at the cost of contracts), %	Index 9

Source Compiled by the authors

The proportion of the population actively using the Internet for the period from 2013 to 2018 varies from 61.4 to 79.3%, while the level of the accessibility of information services stated in the strategy is 100%. In fact, in 2015, 72.5% of households were connected to the Internet, which is below the level of the strategic criterion. The share of domestic ICT costs for 2015 was only 3.7%. The actual change in the share of Russia in the global number of patent applications in the field of ICT from 2010 to 2015 increased only by 4.6% (from 0.43 to 0.45%). The proportion of the population that used the Internet to receive state and municipal services for 2015 amounted to 39.6%. Electronic document circulation between government bodies for 2015 is 44.9%.

The analysis shows that the criteria for the digital economy, as stated in the "Strategy for the Development of the Information Society" for the period 2008–2015, have not been achieved.

The dynamics of the average values of indices, combined by type of potential of the digital economy at the macro level for the period 2010–2018, are presented in Fig. 1. Indices are formed on the basis of the values of the target criteria. The calculation is made according to the maximum value of each of the parameters.

The graph shows a sharp increase in the information potential, determined by the index of population interactivity and household computerization, from 0.43 in 2010 to 0.99 in 2018, which indicates the development of the field of activity under consideration. The decline in scientific and organizational potential indicates the crisis state of the sector in question (Fig. 1).

We are testing the algorithm for monitoring factors and indicators of the development of the digital economy in depressed regions since this simplifies the identification of both negative and positive external effects. In order to test the methodology at the mesoeconomic level, we selected the Mari El Republic and the Kirov Region, which belong to a depressed zone or to a zone of moderate weakness [3].

Table 3 Digitalization indicators at the macro level of the Russian Federation for the period 2010–2018

No	2010	2011	2012	2013	2014	2015	2016	2017	2018
Index 1	–	–	–	61.4	64.9	68.3	71.5	74.1	79.3
Index 2	37.6	40.4	43.9	39.5	35.9	33.4	31.6	30.9	–
Index 3	–	3.6	2.9	2.8	2.3	4.0	4.2	1.9	–
Index 4	54.5	60.1	66.5	71.4	71.0	72.5	74.3	74.4	72.4
Index 5	1.3	1.5	2.9	2.2	2.3	3.7	3.6	2.5	1.3
Index 6	0.43	0.44	0.49	0.5	0.44	0.45	0.35	–	–
Index 7	–	–	–	30.8	35.2	39.6	51.3	64.3	74.8
Index 8	–	–	51.5	49.2	61.7	44.9	40.4	50.1	–
Index 9	14.4	59.3	64.4	63.8	60.5	–	–	–	–

Source Compiled by the authors based on data from federal and regional government statistics agencies [1, 4, 5]

Table 4 Correlation coefficients of indicator values to GDP/GRP

No	National Level (GDP)	Regional level (GRP)	
		Kirov region	Mari El Republic
Index 1	−0.93	0.684	0.672
Index 2	0.87	0.755	0.825
Index 3	−0.28	–	–
Index 4	−0.26	–	–
Index 5	−0.42	–	–
Index 6	0.76	–	–
Index 7	−0.79	0.587	0.895
Index 8	0.59	−0.809	−0.803
Index 9	0.97	0.633	0.736

Source Compiled by the authors based on data from federal and regional government statistics agencies

Table 5 Comparative analysis of digital economy indicators at the macro level of the Russian Federation with target criteria of the strategy

No	The target criterion of the strategy	The value of the criterion for 2015	The achievement level
Information potential			
Index 1	100%	68.3%	Not reached
Index 4	75%	72.5%	Not reached
Index 7	100%	39.6%	Not reached
Scientific potential			
Index 2	Growth in 2.5 times	Decrease by 4.2%	Not reached
Index 5	30%	3.7%	Not reached
Index 6	Growth in 2 times	Growth by 4.6%	Not reached
Organizational potential			
Index 3	Reduction in 2 times	Growth by 11.1%	Not reached
Index 8	70%	45%	Not reached
Index 9	100%	60.5% (in 2014)	Not reached

Source Compiled by the authors based on data from federal and regional government statistics agencies

The dynamics of the indices in the Kirov region and the Mari El Republic for the period from 2010 to 2018 shows that the peak of the digitalization of the regional economy was in 2014 (Fig. 2).

The correlation-regression analysis allows us to identify the strongest relationship with GRP in the Kirov region in the index of investment in ICT equipment (I2 = 0.755), which indicates the development of scientific potential. In the Republic of

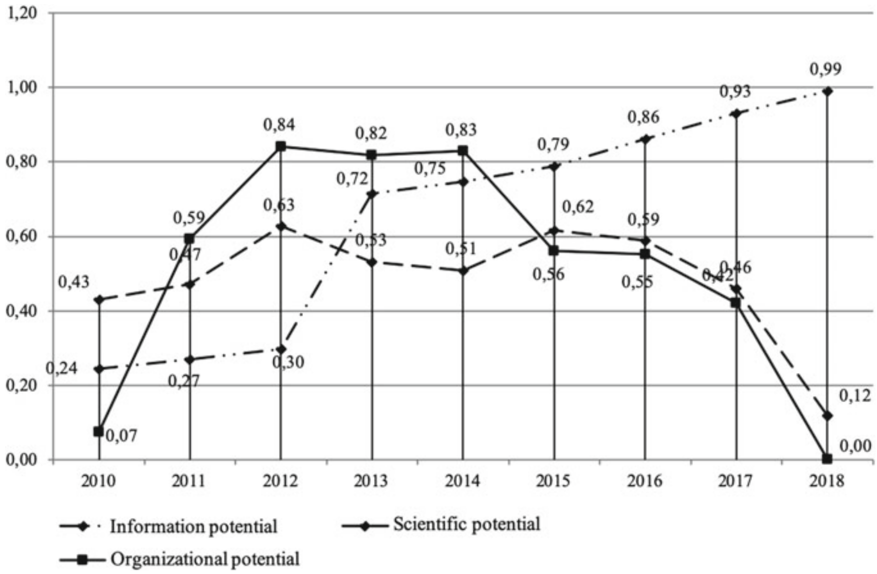

Fig. 1 The dynamics of the digital economy indices of the Russian Federation for the period 2010–2018

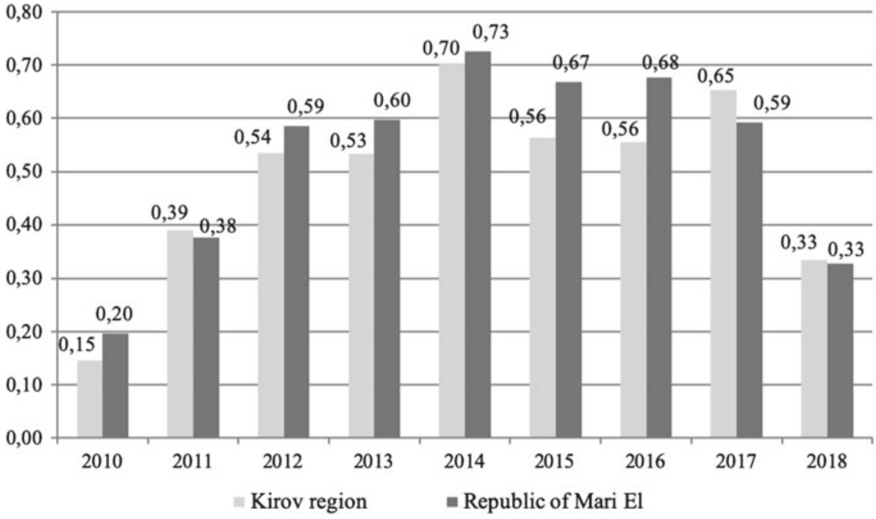

Fig. 2 The dynamics of the digital economy indices in the Kirov region and the Republic of Mari El for the period 2010–2018

Mari El, the strongest correlation of influence with GRP in the index of computerization of public services of the population is an increase in information potential (I7 = 0.895).

4 Discussion

We can largely agree with K. Schwab, the representative of the systems approach, who emphasizes the presence of both positive and negative aspects in the digitalization of the economy. The latter include a decrease in the number of jobs, an increase in the number of cyberattacks and hacks, the risk of collapse, the need to increase the number of manipulations, privacy risks, and other possible negative effects [11].

Representatives of the process approach, N. S. Necheuhina, N. A. Polozova, and T. I. Buyanova, offer two scenarios for the economy's development as a result of technical re-equipment through the introduction of digital technologies [9]. The first development scenario presented by the authors involves the implementation of a sustainable development strategy. This scenario can be implemented in both analyzed regions.

"Digital and technological evolution, the abundance and diversity of the offered products led to the transformation of consumer values," notes V. I. Grushenko in his monograph, "Business Management Strategies" [6].

Representatives of the industrial and modernization approaches provide for the digital design and modeling of technological processes and the transition to the so-called "paperless technologies"; the transition to mandatory digitalized technical documentation and electronic document management involves end-to-end automation and integration of production and management processes [10, 14].

5 Conclusion

The transformation of technological structures has a fundamental impact on the effectiveness of territorial development at the macro- and meso-economic levels—largely determined by the introduction of digital economic systems.

Based on the results of the studies, it can be seen that the strategic development targets are not fulfilled at both the macro and meso-economic levels. The presence of strategic potential implies the need to put forward new ideas about emerging strategic opportunities and areas of activity at all organizational levels [13].

The scenario approach in our case includes the development of two types of scenarios: sustainable and innovative development. For the studied territories, the Republic of Mari El and the Kirov region, it is possible to recommend the implementation of the first type of scenario and, only after that, innovative development can be realized.

In order to achieve strategic goals at the macro and mesoscale in the context of the transformation of the market system, the development of the digital economy should be considered as a process associated with accelerating the realization of strategic potential. Measures for increasing digitalization are necessary to achieve strategic goals and objectives.

Acknowledgments This paper was prepared with the support of FSBEI "Russian Foundation for Basic Research" under grant No. 18-010-00990\19.

References

1. Abdrakhmanova, G.I., Gokhberg, L.M. (eds.): Digital economy indicators: 2018: a statistical digest. Higher School of Economics, Moscow (2018)
2. Administration of the President of Russia: The decree of the President of the Russian Federation "On the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030", 9 May 2017, No. 203. Moscow, Russia. Retrieved from https://www.kremlin.ru/acts/bank/41919 (2017)
3. Chernykh, V.V.: Meso-economic territorial zoning as an aspect of innovative development. Bull. Nizhny Novgorod State Univ. Eng. Econ. **3**(94), 94–106 (2019)
4. Federal State Statistics Service: Monitoring the development of the information society in the Russian Federation. Retrieved from https://www.gks.ru/free_doc/new_site/figure/anketa1-4.html (2018)
5. Gokhberg, L.M., Sabelnikova, M.A. (eds.): Regions of Russia. Socio-economic indicators. Statistical Digest. Rosstat, Moscow (2018)
6. Grushenko, V.I.: Business management strategies. From theory to practical development and implementation (monograph). UNITY-DANA, Moscow (2014)
7. Ivanova, T.K.: Mesoeconomics: property and economic interests. Econ. Theor. Pract. **1**(21), 28 (2011)
8. Ministry of Economic Development of the Russian Federation: The development strategy of the information society in the Russian Federation 7 Feb 2008, No. Pr-212. Moscow, Russia. Retrieved from https://economy.gov.ru/minec/activity/sections/inforientedsoc/doc20080207_01 (2008)
9. Necheuhina, N.S., Polozova, N.A., Buyanova, T.I.: Industry 4.0: transforming industry and the digital economy. In: Babkina, A.V. (ed.) Digital transformation of economics and industry: problems and prospects, pp. 256–277. Publishing House of the Polytechnic University, St. Petersburg (2017)
10. Prudsky, V.G.: Digital modernization of the economy and development of models for managing cyberphysical organizations. . Bull. Perm Natl. Res. Polytech. Univ. Socio-Econ. Sci. **4**, 153–166 (2018)
11. Schwab, K.: Fourth industrial revolution. EKSMO, Moscow (2016)
12. Solozhentsev, E.D.: Digital governance and economics. Topical Prob. Econ. Manage. **1**(17), 136–153 (2018)
13. Suvorova, A.P.: Toolkit of strategic controlling and financial policy for managing the development of the economy in the context of its digitalization. In Zhilkina A. N. (ed.) Finance in the digital economy: preserving traditions and new horizons, pp. 42–54. Publishing House of the State University of Management, Moscow (2018)

14. Volodin, P.V.: The modernization of the system model of an industrial enterprise in a digital economy. In Nesterenko E. A. (ed.) Financial risk management in the digital economy, pp. 152–160. Saratov Socio-Economic Institute of Plekhanov Russian University of Economics, Saratov (2018)
15. Yakushenko, K.V., Shimanskaya, A.V.: Digital transformation of the information management system for the economy of the EAEU Member States. Sci. Technol. News **2**(41), 11–19 (2017)

The Evaluation of Economic Efficiency of Investments in Innovative Development of Agriculture of the Region

Yu. I. Bershitskiy and A. R. Sayfetdinov

Abstract The methodology for assessing the economic efficiency of investments in the innovative development of agricultural sectors is proposed, based on a comparison of the characteristics of the boundary production functions constructed for groups of producers using traditional and modern innovative technologies. It is proposed to consider the technological gap between the compared boundary production functions as a source of additional income generated by the transition from one technology to another. The correctness of the developed methodology was tested via assessing the effectiveness of investments in the innovative transformation of beef cattle breeding in the Krasnodar region. This transformation was a transition to the production of cattle meat on the basis of animals of specialized meat breeds with the use of innovative technologies for their reproduction, rearing, and fattening. The high efficiency and low risk of implementing such innovative investment projects have been proven.

Keywords Economic efficiency · Investments · Innovative technology · Technological gap · Technological frontier · Agriculture · Beef breeding

1 Introduction

The introduction of innovative agro and zootechnologies adapted to the soil and climatic conditions of the placement zone in the production of agricultural products allow producers to obtain products of higher quality with lower unit costs of labor, material, and financial resources.

At the same time, the accelerated implementation of the innovation development strategy of domestic agriculture requires significant capital investments related to the modernization of existing and construction of new production facilities, the acquisition of high-performance agricultural machinery, equipment, seed, breeding stock of

Yu. I. Bershitskiy · A. R. Sayfetdinov (✉)
Kuban State Agrarian University, Krasnodar, Russia
e-mail: saifet@mail.ru

Yu. I. Bershitskiy
e-mail: bershkubgau@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_32

highly productive farm animals, etc. In the near future, the innovative development of domestic agriculture based on the extensive use of foreign industry achievements of scientific and technological progress will be accompanied and restrained by high foreign policy and financial risks [4].

This necessitates a scientific justification of the economic feasibility and effectiveness of the development and implementation of various industrial and domestic innovations in the country's agricultural production. At the same time, the methods used to assess the economic efficiency of innovative investment projects require adaptation to the subject area under study.

2 Materials and Methods

The result of the development and implementation of industry innovations in agricultural production is to increase the efficiency of producers' economic activity in comparison with their marginal potential level, ensured by the best use of the existing system of production factors. At the same time, the growth generators are the advantages of introduced innovations in the form of labor productivity growth, resource-saving, and increasing the volume and quality of products.

The diffusion of industry innovations into agricultural production will gradually ensure the replacement of the technologies used and the means of production that realize them, as well as displace products made on their basis from the market and replace them with products manufactured on an innovative basis and, as a result, having new competitive advantages.

Figure 1 shows a graphical illustration of such processes of innovative substitution. The point P on the abscissa axis fixes the start time of the transition of producers to

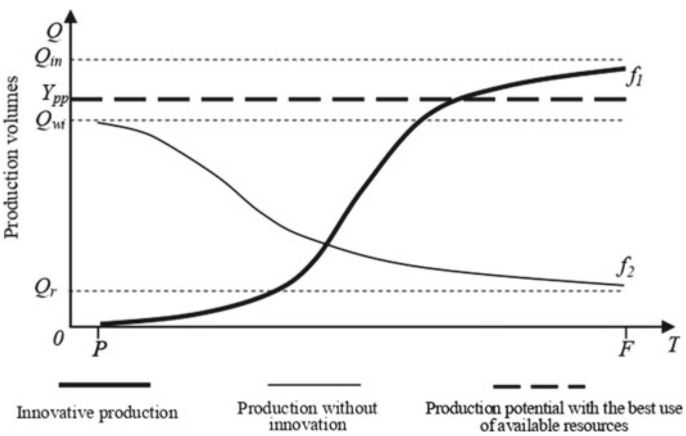

Fig. 1 The graphic illustration of the diffusion of manufacturing innovations

industry innovations. The ordinate axis reflects the volume of production in the use and absence of innovative transformations.

It is assumed that the forecast volume of products produced with the use of innovations (Q_{in}) is higher than the volume of products (Q_{pp}) produced without using them. The production volume Q_r, shown in Fig. 1, will continue to be produced for some time using traditional technology until complete innovation transformation.

The increase in $Q_{in} - Q_{pp}$ production volumes, caused by the application of this innovation, can be considered as innovative growth potential, bringing the results of the production activities of economic entity closer to the technological boundary of its capabilities, taking into account the existing resource base.

However, it should be noted that in practice, producers often do not realize their full production and economic potential due to the suboptimal structure of production resources and the lack of effective organization of their use. Therefore, the effect of the development of innovations, in our opinion, is more correctly considered as the difference between Q_{in} and the potential amount of Y_{pp}, which can be achieved by the manufacturer within the framework of the applied technologies and technical equipment with an optimal structure of production resources and their most efficient use.

It is proposed to determine the volumes of products that can be produced in these conditions by the producers with dimensional and structural characteristics that are close to the optimal resource base, applying traditional and modern innovative technologies, and using boundary production functions constructed with the use of the characteristics of a group of manufacturers that most effectively conduct business in similar production conditions.

Let the operational activities of such a group of k producers over the studied period of time be described by the set $P = \{x_t, y_t, p_t | t = 1,\ldots, k\}$, where $x_t = (x_{t1},\ldots, x_{tn})$ is the vector of the cost volumes n of the production resources of the t-th producer ($x_t \in \Re^{n+}$); y_t is the volume of agricultural production by the t-th producer ($y_t \in \Re^{n+}$); $p_t = (p_{t1}, \ldots, p_{tn})$ is the vector of market prices for the main production resources ($p_t \in \Re^{n+}$), and $C_t = p_t{'}x_t$ is the cost of the consumed resources of the t-th producer in the production of y_t output volume. The actual structure of production resources x_t of the t-th producer is optimal for the production of the y_t volume of production, taking into account the current price situation on the market at equity with the price vector p_t. If such equity is absent, a resource structure x_s can be found, ensuring production in volumes not lower than y_t, but having a lower cost ($C_t \geq p_t{'}x_s$).

If, when forming the producer's resource base, the prevailing pricing environment was not fully taken into account and, therefore, the maximum allocative efficiency was not ensured, an increase in production volumes to a potentially possible level can be achieved not only by increasing technical efficiency within the existing resource base but also due to the adjustment of its structure with the involvement in the production of additional resources acquired by saving money. In this case, the production's potential volume is proposed to be determined by solving the following linear programming problem [1, 2, 5]:

$$\sum_{i=1}^{k} y_i\lambda_i \to \max_{\substack{\lambda=(\lambda_1,\ldots,\lambda_k)\\ x=(x_1,\ldots,x_n)}}; \quad \begin{cases} \sum_{i=1}^{k} x_{ij}\lambda_i \le x_j, \forall j; \\ p_t' x \le C_t; \\ \sum_{i=1}^{k} \lambda_i = 1; \\ \lambda_i \ge 0, \forall i, \end{cases} \tag{1}$$

where $\lambda = (\lambda_1,\ldots,\lambda_k)$—the vector of non-negative "weights."

The solution of Problem 1 allows us to determine the potential production volume of a particular producer in the considered representative sample of business entities, using traditional or innovative production technologies, with an optimal resource base structure and its use at the level of advanced production.

The potential growth in production volumes y of individual manufacturers realized, due to better formation and use of their production resources, is determined by indicators achieved by the most efficient enterprises in this sample.

The proposed methodology can be used to assess the effectiveness of innovative transformations—not only of individual agricultural producers but also of their clusters. For this, it is necessary to calculate the potential production volumes of a group of manufacturers conducting business in similar zonal production conditions. A simple summation of the potential production volumes of individual producers in the composition of this cluster does not allow to obtain sufficiently correct results since it does not fully take into account the resource limitations of the entire cluster.

In order to solve this problem, use of the following mathematical model is proposed:

$$\sum_{j\in J}\sum_{i\in I} y_i\lambda_{ij} \to \max; \quad \begin{cases} \sum_{i\in I} x_{in}\lambda_{ij} \le z_{jn}, \forall j, n; \\ \sum_{n\in N} p_n z_{jn} \le \sum_{n\in N} p_n x_{in}, \forall j,\ j = i; \\ \sum_{j\in J} z_{jn} \le \sum_{i\in I} x_{in}, \forall n; \\ \sum_{i\in I} \lambda_{ij} = 1, \forall j; \\ \lambda_{ij} \ge 0, \forall i,\ j, \end{cases} , \tag{2}$$

where y_i—the volume of production by the i-th agricultural entity; λ_{ij}—the "weight" of the i-th subject of the cluster in the possible volume of production by the j-th producer; x_{in}—the volume of the production resource of the n-th kind actually expended by the i-th subject of the cluster; z_{jn}—the optimal size of the n-th production resource for the j-th producer; p_n—the market price of the n-th productive resource; I—the actual multitude of agricultural producers; J—the set of agricultural producers with potentially possible volumes of agricultural production; N—the set of production resources.

The result of solving Problem 2 is the potential production volume of agricultural products by a group (cluster) of commodity producers engaged in economic activities in similar soil and climatic conditions of the distribution zone, which have close to optimal sizes and structure of production resources and organize their most efficient use.

Potentially possible volumes of agricultural production calculated in this way allow us to determine the size of the technological gap between existing and innovative production technologies, which is the source of the economic effect of such an innovative transformation.

However, it should be noted that the introduction of industry innovations requires, as a rule, significant additional capital and current costs. Therefore, such innovative projects will be effective only if the additional income from their implementation will pay back the invested funds in an acceptable time frame.

In order to assess the economic efficiency of investments in the development of agricultural innovations, it is proposed to use the indicator of net present value, which is the sum of the discounted investment and operating cash flows generated by the introduction of innovations.

$$NPV = \sum_{t=1}^{T_1} Q_t * \left(P_{t_2} - C_{t_2}\right) * (1+r)^{-t} - \sum_{t=1}^{T_1} Y * \left(P_{t_1} - C_{t_1}\right) * (1+r)^{-t} - \sum_{t=0}^{T_2} I_t * (1+r)^{-t}, \quad (3)$$

where Q_t, the volume of production is in the t-th year after the introduction of innovation; where P_{t1} and P_{t2}, the sales prices are in the t-th year before and after the introduction of innovations, respectively; where C_{t1} andC_{t2}, the cost of production is in the t-th year before and after the introduction of innovation, respectively; where I_t, the volume of investments is in the development of innovations in the t-th year; where Y, the potential border of production is before innovation; where r, the discount rate is the weighted average cost of the invested capital; T_1 is the term of "life" of innovation and investment project; T_2 is the duration of the project investment.

The positive value of the indicator (3) shows the economic feasibility of investing in the implementation of the industry innovation under consideration. Given the specifics of agricultural production associated with the strong dependence of its results on the year's prevailing weather conditions, the fluctuations in the price situation in the manufactured products and means of production markets, foreign policy, and economic challenges, when assessing the economic efficiency of investments in the development of industry innovations, it is necessary to account for the risks of such investment of projects.

The indicator (3) allows us to take into account the volume and price of invested capital, resource constraints of producers, and to perform economic comparisons of the parameters of technological boundaries of production using existing innovative technologies. The proposed methodology allows a more reasonable economic assessment of the effectiveness of investments in various areas of the innovative development of the domestic agricultural economy.

Testing of the described methodological provisions was carried out by evaluating how effective the investments were in the innovative transformation of the beef cattle breeding sub-sector in the Krasnodar region, one of the leading agricultural regions in southern Russia.

3 Results and Discussion

Recently in Russia, there have been noticeable, positive dynamics in the production of agricultural products: the production of grain, sugar beets, vegetables, fruits, and grapes has significantly increased; threshold values for the Food Security Doctrine for the production of certain types of meat and meat products have been reached. Simultaneously, domestic agriculture still does not meet the needs of the population for certain types of agricultural products in volumes that correspond to the recommended medical standards.

The country's provisions of high-quality, affordable food require the priority development of agricultural sub-sectors, which mostly hamper the implementation of the import substitution program. The analysis showed that currently, one such sub-sector in Russia is beef cattle breeding.

Domestic beef cattle breeding is mainly based on fattening dairy breed animals, while producers in countries with developed agro economics use technologies for the reproduction, rearing, and fattening of meat breed cattle, which have significant advantages in feed conversion, productivity, and product taste. Domestic producers also need to switch to innovative technologies of specialized meat cattle breeding in the production of cattle meat. Such a transition requires significant investment in the acquisition of the breeding stock of elite cattle, the construction of new production facilities equipped with modern means of mechanization, and automation of production processes [3].

The number of cattle in the Krasnodar region has been continuously decreasing over the past 25 years. Simultaneously, meat-animal production in 2016 amounted to 116 thousand tons, of which only 55 thousand tons (47.4%) accounted for the region's agricultural organizations.

The analysis also showed that by the end of 2016, the number of cows in agricultural organizations in the region decreased to 131,000 animals, while their milk production increased to 6700 kg/animal. Predictive calculations have shown that the milk productivity of cows in 8–10 years will exceed 8000 kg, while the number of dairy herds can be reduced to 100,000 animals, which will significantly reduce the resource base for the production of cattle meat.

Table 1 Actual and estimated volumes of cattle meat production in agricultural organizations of the Krasnodar region

Agroclimatic zone	Actual production volumes in 2016, thousand tons	The estimated potential production volume taking into account:	
		Increasing efficiency of resource use, thousand tons	Improving the structure of the resource base, thousand tons
North	18.8	21.3	22.7
Central	30.8	35.4	38.2
South- Piedmont agroclimatic zone	1.09	1.09	1.15
Krasnodar region	50.6	57.7	62.0

Source Compiled by the authors

In order to determine the potential production volumes of cattle meat in the region under the existing system of beef cattle breeding, based on the cultivation and fattening of animals of dairy breeds, and the resource constraints of agricultural commodity producers, tasks (1) and (2) were solved for a representative sample of 165 agricultural organizations of the region.

The analysis of the results showed that in the Krasnodar region, there are potential opportunities for growth in cattle meat production by improving the structure of the resource base of agricultural organizations and increasing the efficiency of its use. Thus, the implementation of measures for improving the efficiency of land, labor, and material and technical resources will increase the production of cattle meat in the sample by 7.1 thousand tons. The improvement of the structure of these production resources will increase the output of the industry by another 4.3 thousand tons and bring the total production of cattle meat to 62 thousand tons (Table 1).

The analysis of the factors contributing to the achievement of the potential production volumes of beef cattle breeding in the region, carried out using the Tobit model, showed that the main growth reserves with the existing technological basis are the formation of a rational size of cattle herd; optimization of the volume and structure of animal feed diets; and increased labor productivity due to the mechanization and automation of technological processes.

Significantly more growth in the output of sub-industry products can be achieved by switching to the technology for growing and fattening cattle of specialized meat breeds.

The calculations showed that when switching to such innovative technologies, the specific production costs for the maintenance and feeding of the breeding stock of cattle and calves can noticeably increase. At the same time, the best practice shows that placement of the breeding stock with suckling calves and young animals in natural and climatic zones of the region with sufficiently large areas of pastures makes it possible to significantly reduce these costs, which allows animals of these

Table 2 Estimated indicators of the effectiveness of investments in the innovative development of beef cattle breeding in the Krasnodar region

Indicator	Value
Required investment, ₽ billion	15.3
Discount rate, %	15.1
Net present value, ₽ billion	8.1
Internal rate of return, %	19–42
Discounted payback period, years	4.7–9.2
The probability of break-even of projects, %	94

Source Compiled by the authors

gender and age groups to be provided with cheap pasture feed for a considerable part of the production cycle.

The calculations showed significant economic advantages for the construction of reproductive farms in the South-Piedmont agricultural zone of the region, which has relatively large pasture areas. In this case, the final fattening of animals can be effectively organized in any agro-climatic zone of the region.

The evaluation of the effectiveness of the described innovation and investment project was performed by superimposing the agricultural organizations of the Krasnodar region on the model. The evaluation results are shown in Table 2.

The calculations showed that investments in the innovative development of beef cattle breeding in the Krasnodar region are effective and low-risk. At the same time, construction of fattening farms and complexes is more cost-effective than the construction of reproduction facilities.

The accuracy and reliability of the evaluation of the effectiveness of investments in the innovative development of beef cattle breeding in the Krasnodar region were confirmed by alternative calculations of the criterion indicator (3), whose value amounted to ₽ 8.5 billion. Moreover, investments in the amount of ₽ 15.3 billion will pay off within 7.3 years, and the internal rate of return of the investment project will be 34.5%.

In the medium and long term, the development of beef cattle breeding in the region should be realized through a significant increase in the number of elite meat cattle.

The conducted studies allowed us to perform predictive calculations of the development indicators of beef cattle breeding in the Krasnodar region until 2026 (Table 3).

The results of predictive calculations show that the implementation of the proposed science-based measures will increase the proportion of beef cattle from 7 to 44%. This, in turn, will ensure growth in cattle meat production by 55%, reduce production costs by 15%, overcome the prevailing unprofitability of production of the subindustry, and increase its profitability to 22%.

Table 3 The forecast for the development of beef cattle breeding in the Krasnodar region for the period up to 2026

Indicator	Value at the beginning of 2017	Forecast for 2026
The number of cattle in agricultural organizations total, thousand animals	352	434
including meat breeds, thousand animals	24	192
The share of beef cattle in the total number of cattle, %	7	44
The volumes of cattle meat production in agricultural organizations of the region, thousand tons	48	75
including on the basis of fattening animals of meat breeds, thousand tons	4	61
The cost of production of cattle meat in live weight, ₽/kg	142	120
The selling price of live weight of cattle, ₽/kg	100	147
The production profitability, %	−30	22

Source Compiled by the authors

4 Conclusion

1. As a result of the research, a methodology for evaluating the effectiveness of investments in the innovative development of agriculture in the region has been developed. It is implemented by comparing boundary production functions built on the basis of the economic activities of the most successful producers, who organized production in similar soil and climatic conditions of the region, having dimensional and structural characteristics of production resources close to optimal and using traditional and innovative industry technologies.
2. To assess the economic efficiency of investments in innovative transformations of agricultural sectors, it is proposed to use an indicator of net present value adapted to industry characteristics that takes into account the size of the necessary investments, as well as additional income generated by innovations from increasing production volumes, reducing unit production costs and increasing product quality.
3. The developed methodological approach allowed us to evaluate the effectiveness of investments in the innovative development of the beef cattle-breeding subsector of the Krasnodar region, based on the transition to the production of cattle meat on the basis of reproduction, rearing, and fattening of animals of specialized meat breeds. It is shown that such an innovative transformation will require a

transition to technologies that are developed with consideration for the peculiarities of animal breeding and the construction of specialized production facilities located in areas most adapted to the features of the innovative technologies.

4. The innovative transformation of beef cattle in the Krasnodar region will require ₽ 15.3 billion in investments. The implementation of this innovation and investment project will provide a net discounted income of ₽ 8.5 billion, with an internal return rate of 34.5% and a payback period of investment of not more than seven years. The calculations also showed a low risk in implementing an investment project, the break-even probability of which is 94%.

Acknowledgment This work was supported by the RFBR grant No. 19-410-233007.

References

1. Afriat, S.N.: Efficiency estimation of production functions. Int. Econ. Rev. **3**, 568–596 (1972)
2. Bershitskiy, Y.I., Safonova, M.F., Sayfetdinov, A.R.: Methodical features for substantiating the directions and evaluations of the effectiveness of innovative development in meat cattle breeding of the region. Espacios **40**(10), 11 (2019)
3. Bershitsky, Yu.I., Saifetdinov, A.R.: Directions for increasing the efficiency of beef cattle breeding in the Krasnodar region. Agric. Econ. Russia **5**, 54–59 (2017)
4. Bershitsky, Yu.I., Saifetdinov, A.R.: Directions and priorities of the import substitution program in the domestic meat market. Agric. Econ. Russia **1**, 84–90 (2018)
5. Coelli, T.J.: Recent developments in frontier modeling and efficiency measurement. Aust. J. Agric. Econ. **3**, 219–245 (1995)

The Problems of Introducing Innovative Technologies in Industrial Gardening in Dagestan

Louisa A. Velibekova, Magomed-Rasul A. Kaziyev, and Gasan D. Dogeev

Abstract The paper focuses on the social and economic importance of gardening and the perspective role of Dagestan in the solution of a problem of an increase in gross collecting fruit products in Russia. The key directions of innovative solutions in gardening are considered. The authors discuss the need for active implementation of the innovative technologies allowing to solve the problems of improving the competitiveness of the industry in an expedited manner.

Keywords Gardening · Innovations · Technologies · Region · Development · Efficiency

1 Introduction

Gardening is a cost-effective and socially significant industry capable of ensuring the employment of the rural population and a high return on the investment. Market demand for fruits is currently far from being saturated in Russia, even with significant volumes of imported expensive and non-environmentally friendly products. The population of Russia consumes several times fewer fruits than necessary from a medical point of view (the average annual medical norm for consuming fruits and berries is 122 kg per person, but, in reality, this norm is satisfied by just 38%) [10].

The relevance of the development of gardening in Russia is intensively increasing due to the need for the implementation of the set of measures provided in the Food Security Doctrine, the state program "Development of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets for 2013–2020" in the coming years. Paying close attention to the problem of fruit production is not just a way to successfully solve various economic issues, but it is also the basis of the health and the quality of life of the population. In this regard, the industry will become one of the most important areas of agriculture in the coming period.

L. A. Velibekova (✉) · M.-R. A. Kaziyev · G. D. Dogeev
Federal Agrarian Scientific Center of the Republic of Dagestan, Makhachkala, Russia
e-mail: l.a._velibecova@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_33

2 Materials and Methods

The data of the Federal State Statistics Service, the Ministry of Agriculture and Food of the Republic of Dagestan, and the articles in Russian periodicals were used as the information source when writing this paper. Economic-statistical, analytical, and abstract-logical methods were used as research methods.

3 Results

The Republic of Dagestan is one of the essential southern agricultural regions of Russia, which can and should play a significant role in the implementation of the task of increasing fruit production, as its soil and climatic conditions have favorable opportunities for the development of gardening. The share of the republic in the Russian area of fruit and berry plantations in 1990 was 4.8%, and now it has increased to 5.3%. The share of the republic in the gross collections of fruit and berry crops in 1990 was 11.2%, and now it has decreased to 6%. Still, the volume of fruit production exceeded the level of 2000–2010 by 1.5 times [11].

Consequently, in recent years, the republic has increased its share in the country's gardening, primarily due to the expansion of the areas under perennial plantations. As the experience of the vast majority of Russian horticultural regions shows, a solution to the problem of increasing the gross harvest of quality fruit crops is possible by creating and cultivating intensive and highly intensive orchards. In recent years, intensive gardening has been developing rapidly in Dagestan. The number of new gardens being cultivated is higher than in the last decade. At the end of 2018, the republic became a leader in the rate of planting gardens in Russia. From the 2.3 thousand hectares of gardens planted in 2012–2019, 44.8% were of the intensive type [4, 11].

Thus, the widespread establishment of such plantations can be a significant prerequisite for transforming the region into one of actively increasing fruit production.

However, intensive gardening is not an easy task. It requires in-depth knowledge in the field of cultivation and the rules of garden care, specific skills, availability of specialized equipment, and quality planting material. The vertical zonality of the republic predetermines the characteristics of the industry, especially for the mountain and piedmont zones, where a complex of machines and assemblies, a set of varieties, varietal-rootstock combinations, and agricultural technologies for each zone and each particular farm are required.

Unfortunately, Dagestan does not currently have modern technological and scientific potential nor the corresponding infrastructure that can ensure the implementation of innovative projects. The crucial elements of industrial gardening are not kept up-to-date; on the contrary, they are being degraded as can be seen from the state of the machinery, tractor fleet, and production equipment, the rural social and engineering infrastructure, land, and labor resources. Nowadays, there are no high-tech garden farms that keep pace with the times and technologies in the republic. The share of agricultural enterprises in the total volume of fruit production for 1990–2018 decreased from 44.2 to 2.5%; the share of personal subsidiary plots of the population, on the contrary, increased from 55.8 to 98.1% [11]. The technological backwardness of the republic is evident, and this is primarily caused by the lack of financing for producers and investors in the agricultural sector—a key problem that generates many negative trends in the industry. In this regard, it is necessary to develop new approaches to increase the production potential of large agricultural enterprises and to organize the work of family-individual forms of management. The development of new approaches is possible only through the technical and technological modernization of production, the formation of market infrastructure, and the development of large integrated structures [14].

In our opinion, the solution to the problem of increasing the quality of yield and fruit, economic efficiency, and the investment attractiveness of the industry is impossible without the use of innovative technologies at all technological stages. The significant assistance of the state is needed in the development of a modern innovation system. Technological and innovative policy in gardening should become an integral part of the holistic economic policy of the republic.

4 Discussion

International experience and practice convincingly demonstrate that increasing the efficiency of gardening is achieved only through the intensification of innovation. Leading foreign agricultural producers in the last third of the last century began to switch to the so-called information and biotechnological agriculture: precision agriculture, technological and environmentally friendly production, and the broad introduction of the new generation of machinery and equipment. Today, when Russia works under the terms of the World Trade Organization, it creates a competitive advantage for foreign producers of exporting countries in the world and the Russian market. It is well known, that it is impossible to achieve competitive advantages in the market without the systematic introduction of innovations [2, 3, 5–7, 10].

The following main priority areas of the innovative development of gardening can be distinguished (Fig. 1):

1. The improvement and introduction of new varieties of fruit crops with high productive potential and high resistance to abiotic and biotic stressors; and selection as the basis for the successful promotion of fruit products on the food market, which provides a significant increase in the profitability of gardening. Due to the selective improvement of the breed, it is possible to increase the productivity of fruit stands by 30–70%. Some success was already achieved in creating new varieties of garden crops because of the ongoing work of breeders. Thus, based on

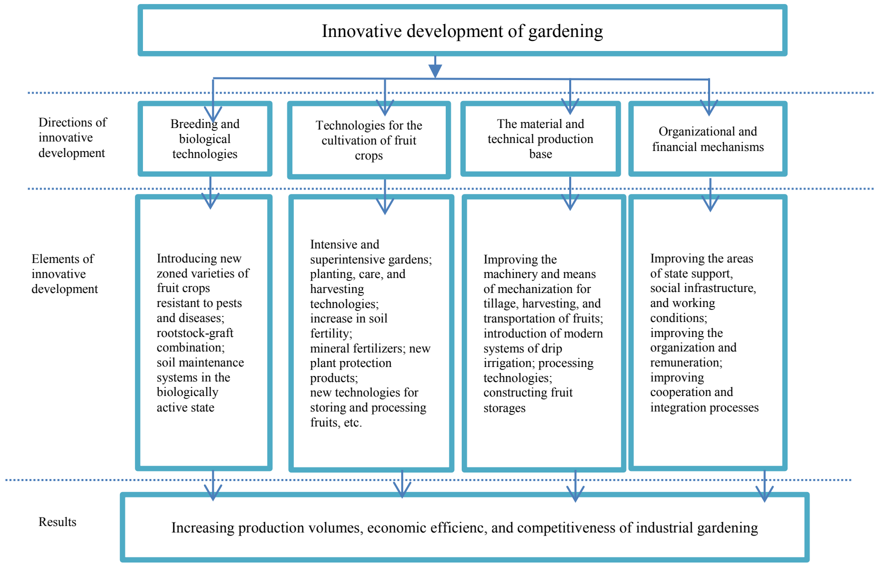

Fig. 1 The main directions of the innovative development of gardening

breeding achievements in the field of immunity genetics, more than 200 varieties of apple trees resistant to scab have been created in the world. The advantage of types of domestic selection is of particular note. Russian breeders have created highly productive varieties, which are an important innovative achievement for increasing yields free of viral pathogens [1, 8, 17].

2. The priority of scientific research in gardening for the innovative development of the industry is to create optimal conditions for mineral nutrition for fruit trees, which is achieved by the correct use of soil fertility and fertilizers. The use of chemicals helps to increase the yield of plantations, improve product quality, provide labor savings, and increase productivity. The highest efficiency from chemicals is obtained with their rational and correct use.

The most effective way to provide fruit and berry crops with nutrients is fertigation, which helps maintain the necessary level of nutrients concentration, save labor and energy costs for fertilization, prevent contamination of groundwater, apply fertilizers only as needed, and increase productivity and quality of fruit and berry products.

1. In the conditions of shortage of water, energy resources, and environmental degradation, the development of modern, resource-saving methods of irrigation is required. In gardening, various irrigation systems are used, but the most progressive approach is micro-irrigation (drip, micro-sprinkling). It increases the yield of marketable fruits, increases the frost and winter hardiness of trees, and accelerates the entry of plantings into the marketable fruiting. This method of irrigation provides constant replenishment of the moisture deficit and automatically maintains the balance of water in the system soil-plant—air. The costs of

drip irrigation are paid off by increasing the yield and improving the quality of the fruit within 1–2 years [13, 18].

2. The most important factor determining the effectiveness of intensive gardening is the protection of plantings from a complex of pests and diseases. The design of intensive gardens allows better protection from pests and diseases, which results in an increase of 20–22% in the yield of being healthy [6, 13, 16, 18].
3. The key point in the implementation of new technologies should be the technical re-equipment of agriculture with a system of agricultural machines that ensure high labor productivity, reliability, multi-operation, work safety, and environmental friendliness. Nowadays, the technical base of domestic gardening consists of imported machinery and equipment from 40 to 80%, while the total provision of gardening with the equipment for intensive technologies does not exceed 15%. As a result, the technology for the production of fruits and berries is simplified. The lack of domestic gardening equipment constrains the mechanization of gardening. It is practically not produced in Russia. A small number of individual machines are developed and produced by the research institutes and some large horticultural enterprises. These industrial technologies for the cultivation of fruit crops are based on the complex mechanization of all production processes and can dramatically increase the labor productivity [6, 15, 18].
4. The effectiveness of gardening is ensured by the development of innovative post-harvest technologies (storage, commodity processing) and the delivery of high-quality fruits to the consumer throughout the year. Currently, a promising system of storage in a controlled atmosphere (CA) is being developed by scholars in the Russian Research Institute of Horticulture named after I. V. Michurin. The best storage results in the CA are achieved in an atmosphere with an ultra-low oxygen content (1–1.5%) and a moderate carbon dioxide content (1–4%). At the same time, fruit damage by tanning, subcutaneous spotting, decay from aging, and fungal rot is eliminated or sharply reduced, so that the taste and appearance of the fruit are preserved. The comprehensive development of the material and technical base of production and storage of products gives a high economic effect. The profitability of the cultivation, storage, and sale of pome fruits with this approach reaches 70–120% [3].

An indispensable condition for the innovative development of the industry is the availability of highly qualified personnel (one of the main factors contributing to the effective cultivation of garden plantings).

Thus, the innovative development of gardening is a way of a large-scale, continuous modernization of production, using resource-saving technologies, greening, the achievements of the selection and genetic, staff development, infrastructural, and social development of rural areas.

5 Conclusion

The current economic situation in Dagestan (the deep financial crisis of agricultural producers, the lack of competent personnel, the destruction of the nursery base, etc.) does not allow intensifying the innovative processes in agriculture in general and in gardening in particular. The studies show that the vast majority of the producers are not able to introduce and develop innovative activities; all of them need financial loans.

Another problem of introducing innovations in production is the lack of effective implementation mechanisms. As noted by V. I. Nechaev, "There are still no effective mechanisms encouraging business entities to innovate. The creators of the innovative products—to the organization of mass adaptation in the real production conditions; agricultural producers, processors, and food workers—to the desire for an accelerated technical and technological renewal of production" [12].

In our opinion, the modernization of gardening is possible only with the focused activity of all participants in the innovation process, involving the interaction of scientific institutions, agricultural organizations, and agricultural management bodies at all levels. Figure 2 shows the proposed organizational structure for managing innovation and investment processes at the regional level.

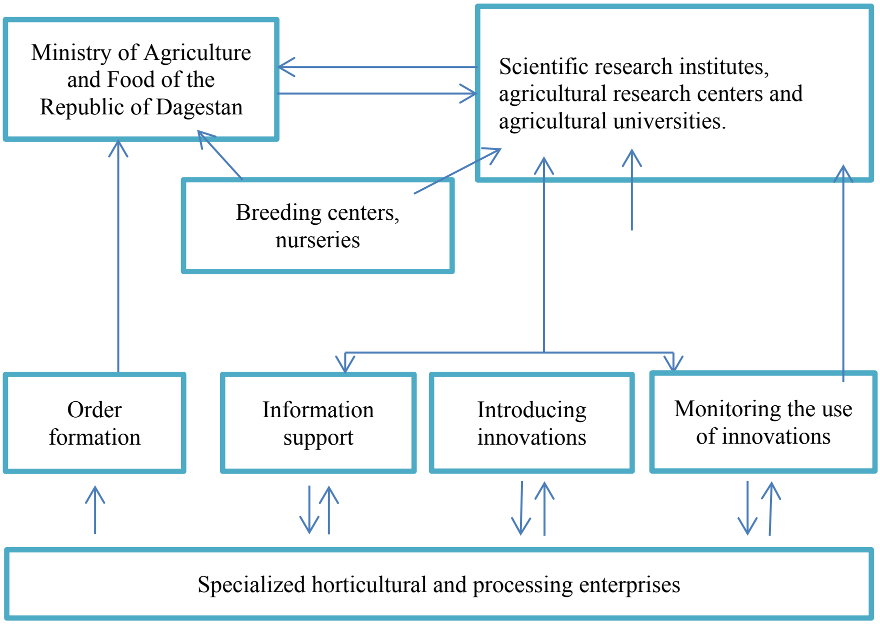

Fig. 2 The model of the regional organizational structure for the management of innovation and investment processes

The main link in the organizational structure for managing innovation and investment processes should be scientific institutions and universities that coordinate work with breeding centers. This will make it possible to develop scientific and economic forecasts and comprehensive programs for the development of fruit growing in the republic, to carry out patent-licensing and inventive work, and to disseminate the results of scientific research. In our opinion, significant state assistance is needed in the formation of a modern innovative gardening system, which should become an integral part of the republic's holistic economic policy. Of particular importance are government support measures that contribute to the research activities of projects, the diffusion of technologies, and their implementation in real production. The latter includes targeted funding for research and development aimed at the innovative development of gardening; the provision of state subsidies for the most expensive technological stages of growing orchards [9].

Gardening is highly capital intensive, and for its effective functioning, it is necessary to attract a large number of investment resources. One of the options for attracting private investment in the industry is the use of various forms of public–private partnerships in which public and private structures work together to solve industry problems and have a common understanding of the goals and methods of cooperation. The primary organizational forms of this partnership will be the formation of technology platforms and regional clusters.

Thus, the industrial gardening of Dagestan should be focused on the widespread introduction of innovations. The innovations will ensure both an increase in production volumes and a leading industry position in the context of global competition.

References

1. Egorov, E.A., Buntsevich, L.L.: Technological basis and organization of production of seedlings and other planting material of horticultural crops. Hortic. Viticulture **2**, 39–43 (2018)
2. Egorov, E.A., Ilyina, I.A., Makarova, E.V.: Fundamental and applied developments forming the modern look of horticulture and viticulture. North Caucasus Zonal Research Institute of Horticulture and Viticulture, Krasnodar (2011)
3. Editorial.: Innovation development course. Agric. Econ. Russia **10**, 25–30 (2012)
4. Kachurak, V.: Dagestan exceeded the plan for laying of new gardens. Retrieved from https://sdelanounas.ru/blogs/101941/ (2017)
5. Kulikov, I.M.: Innovation strategy as a factor in overcoming the agrarian crisis. AIC Econ. Manage. **8**, 3–11 (2013)
6. Kulikov, I.M.: Current problems of the innovative development of gardening in Russia. Int. Agric. J. **2**, 9–14 (2012)
7. Kulikov, I.M., Minakov, I.A.: Problems and prospects of gardening in Russia. Hortic. Viticulture **4**, 40–46 (2018)
8. Kulikov, I.M., Borisova, A.A., Tumaeva, T.A.: Relevant problems of the nursery in Russia. Hortic. Viticulture **2**, 33–38 (2018)
9. Michurinskaya Pravda. (n.d.): The future of domestic gardening is in the integration of science and business. Retrieved from https://www.michpravda.ru/articles/23483-budushchee
10. Minakov, I.A.: Problems of import substitution and the formation of export potential in the fruit and vegetable subcomplex. Econ. Agric. Process. Enterprises **2**, 19–23 (2019)

11. Ministry of Agriculture and Food of the Republic of Dagestan: Agriculture of Dagestan: Statistical bulletin of the Ministry of Agriculture and Food of the Republic of Dagestan. Makhachkala, Russia (2019)
12. Nechaev, V.I.: The mechanism of the innovative development of agribusiness in Russia. Agric. Econ. Russia **11**, 41–48 (2012)
13. Nikitin, A.V., Kvochkin, A.N.: Innovative machine technologies as the basis for the formation of a strategy for the development of intensive gardening in Russia. Achievements Sci. Technol. AIC **4**, 39–41 (2013)
14. Sharipov, Sh.I.: Problems of the development of intensive gardening in Dagestan. Proc. Geogr. Soc. Repub. Dagestan **42**, 54–57 (2014)
15. Trunov, Yu.V., Zavrazhnov, A.A.: Improving the effectiveness of Russian horticulture through the use of intensive types of gardens and machine technologies for their cultivation. Achievements Sci. Technol. AIC **4**, 41–49 (2013)
16. Trunov, Yu.V., Trunov, A.A., Eremeev, D.N.: The effectiveness of mineral fertilizers and liming in the apple orchard. Achievements Sci. Technol. AIC **8**, 18–19 (2010)
17. Zaschita Rastenii: The global market for plant breeding will grow by more than 20% by 2023. Retrieved from https://www.agroxxi.ru/gazeta-zaschita-rastenii/zrast/mirovoi-rynok-selekcii (2019)
18. Zavrazhnov, A.I.: The development of innovative technologies and technical means for intensive gardening in Russia. Achievements Sci. Technol. AIC **4**, 44–46 (2013)

Innovative Development of the Meat Sub-sector Based on the Rational Allocation of Production

Lydia P. Silaeva, Zhanna T. Kulchikova, and Elena V. Barinova

Abstract The dynamic growth of poultry and pork products in Russia is taking place against the background of a significant reduction in beef production and the relatively poor quality of the feed base. The number of livestock for the period 1990–2017 is analyzed in the paper. Special attention is paid to the quality indicators of the feed base, taking into account the study of the dynamics of the cultivated areas of fodder crops in the country over thirty years. The main directions of strengthening of fodder resources in animal husbandry, providing growth of meat production by reduction of the expense of forages per unit of production, are allocated. The conditions of economic growth and sustainability of the production of enterprises of the meat sub-sector are determined based on their innovative development. The important role of specialization in animal husbandry as the least expensive direction of development of a sub-sector on the way of increasing the efficiency of production, competitiveness, and quality of the final product is proved. The prospects for the development of organic meat production are designated.

Keywords Placement · Specialization · Stock raising · Feed quality · Innovations · Organic products

L. P. Silaeva
Federal Scientific Center of Agrarian Economics and Social Development of Rural Territories—All Russian Research Institute of Agricultural Economic, Moscow, Russia

Z. T. Kulchikova
Kostanay Branch of the Chelyabinsk State University, Kostanay, Republic of Kazakhstan

E. V. Barinova (✉)
V. M. Gorbatov Federal Research Center for Food Systems of Russian Academy of Sciences, Moscow, Russia
e-mail: e.barinova@fncps.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_34

1 Introduction

The sustainable and dynamic development of the meat sub-sector in the country, including increasing export resources for certain types of meat and meat products, is possible with the effective functioning of animal husbandry, which increases the productivity of animals on the basis of the reliable and stable supply of high-value feed. The introduction of the achievements of scientific and technological progress on the basis of innovative technologies will allow the continuous updating of production processes in the meat sub-industry. It will serve as the basis for its uninterrupted and efficient work in the long term. The innovative development should ensure the rational use of production potential, reduce the complexity of production, be economically motivated and justified, meet the technical and technological feasibility, and contribute to improving the quality of feed and the competitiveness of meat products in the world and the domestic markets of the country [3]. The growth of labor productivity in the enterprises of the meat industry in the transition to an innovative development path should be based on the use of resource-saving and environmentally friendly equipment and technologies.

2 Materials and Methods

As the main empirical material, the data of the Federal State Statistics Service of Russia [4], presented on the official website of the organization, are used. The object of the study is the production of the meat sub-industry in the country. Abstract-logical, analytical, computational-constructive research methods were used in the paper.

3 Results

Animal husbandry is the primary source of raw materials for the processing enterprises of the meat sub-sector, the indicator of its regular operation, and the possibility of effective functioning. In turn, the optimal proportionality and balance between the production and consumption of feed resources determine the level of livestock sustainability based on the land, which serves as its main feed source. Considering that cattle breeding, fodder production, and meat industry are in deep, close, technological connection, it is necessary to pay special attention to their rational placement on the territory of the country. The specialization of regions in the production of certain types of livestock products, the concentration of their commodity production in the most favorable areas—taking into account numerous factors—has a significant impact on the level of stability and dynamic development of competitive production of high-quality products of the meat industry.

Table 1 The number of farm animals in Russia, million animals

Types of livestock	Years							2017 in
	1990	1995	2000	2005	2010	2015	2017	% to 1990
Cattle	57.0	39.7	27.5	21.6	19.8	18.6	18.3	32.1
Including cows	20.6	17.4	12.7	9.5	8.7	8.1	8	38.8
Pigs	38.3	22.6	15.8	13.8	17.3	21.4	23.1	60.3
Sheep and goats	58.2	28.0	15.0	18.6	21.7	24.6	24.4	41.9
Including sheep	55.2	25.3	12.7	16.4	19.7	22.4	22.3	40.4
Including goats	3.0	2.7	2.2	2.2	2.1	2.2	2.0	66.7
Horses	2.6	2.4	1.6	1.3	1.3	1.2	1.2	46.2
Poultry	659.8	422.6	340.7	357.5	449.7	543.9	555.8	84.2
Reindeer	2.3	1.7	1.2	1.3	1.6	1.8	1.8	78.3
Rabbits	3.4	1.6	1.3	1.6	2.8	3.7	3.7	108.8

Source Federal State Statistics Service [4], calculated by the author

For the last three decades (Table 1), the number of cattle, including cows, has almost tripled in the country, which amounted to 18.3 and 8.0 million animals at the end of 2017, respectively. The number of sheep to the level of 1990 decreased by half from 55.2 to 22.3 million animals. In recent years, the production of pork and poultry in the country has been growing at a noticeable pace, which number at the end of 2017 amounted to 23.1 and 555.8 million animals against 13.8 and 357.5 million animals at the end of 2005, respectively.

A significant reduction in the production growth rates and low availability of beef for the country's population is due to reduced production because of its unprofitability and relatively high retail price compared to other types of meat. The long cycle of raising cattle, the significant amount of costs for the implementation of the production process, and their payback period make beef production unattractive and not economically viable for agricultural producers. Currently, the existing level of the development of beef production in most Russian regions of the country does not meet modern requirements. The small number of beef cattle, the technical and technological backwardness of the production potential, the poorly efficient use of fodder lands due to their unsatisfactory condition, and the lack of investment resources and appropriate infrastructure facilities are only part of the objective reasons for the reduction of beef production in the country. The tight market relations that developed at the beginning of the twenty-first century predetermined the transition of agricultural producers to the production of the most profitable item-crops—and the reduction of inefficient livestock production. The disparity of prices for agricultural and industrial products; the deterioration of the material, technical, and fodder base; breeding; and breeding work had a negative impact on the development of the meat sub-sector of the country.

Taking into account the relatively high cost of beef and processed beef products, in the conditions of low effective demand of the population, the increase in the growth rate of beef cattle breeding should be carried out by reducing the production cost of the final products. In this regard, the development of specialized livestock production is the most cost-effective and resource-saving direction of the sub-sector's development. The specialization and concentration of animal husbandry, taking into account the natural and climatic conditions of the regions of the country, makes it possible to ensure significant growth of high-quality, competitive products for the least cost. An increase in the number of cows and their concentration in specialized areas, combined with the use of scientific and technological progress, can be a critical factor in increasing the efficiency of livestock farming and building up the relatively cheap export potential of the country's meat products.

The development of sheep husbandry in the country should be carried out in two directions: industrial and traditional. Both paths are equally necessary for the development of the subsector as a whole and the preservation of the national and cultural traditions of individual Russian regions. The industrial direction should become the basis for the highly efficient production of lamb and mutton meat. And for the population of the arid steppes of the South of Russia, sheep breeding is the only possible activity and way of life. In these areas, sheep farming performs an important social function of maintaining the centuries-old way of life of the inhabitants of these national territories and employment of the population. At the same time, it is essential to note that traditional sheep meat farming has good prospects. The meat of pastured animals is considered an environmentally friendly product, the demand for which is steadily growing in the modern world. It is agricultural producers of organic meat products, with the appropriate certificate [6], that will occupy the most favorable position in the market of meat and meat products. It is also advisable to consider the development of traditional meat sheep breeding from the point of view of conservation of natural resources and restoration of the ecosystem of the country. In order to avoid land degradation and keep them in agricultural circulation, sheep and cows must be kept on pastures. Furthermore, of course, the development of ecotourism should bring additional income to these regions. Thus, sheep farming in the country has two ways of development: the extensive, with the support of the state for the traditional functioning of the sub-sector, and the intensive, for industrial production through business structures.

In the development of meat sheep breeding, it is necessary to take a balanced approach to the creation of sectoral programs for the development of the sub-sector in the long term for the socio-economic stability of rural areas of the country. In modern market conditions, under the fierce competition and lack of financial resources, when placing sheep on the national territory, first of all, it is necessary to take into account the main role of territorial and sectoral division of labor in agricultural production as the least costly factor in the development of this sub-sector in the country. It is the specialization that should underlie the active development of sheep farming. The creation of specialized zones with a concentration of livestock in some areas of the country will ensure the high quality of the final products of sheep breeding and the sustainable and dynamic development of this sub-sector. An essential condition for ensuring competitive sheep breeding is the development and implementation of low-cost and energy-saving technologies for keeping and feeding sheep. Full feeding of animals is impossible without the creation of highly productive pastures by their saturation with bushes, semi-bushes, and perennial grasses. Increasing the productivity of livestock based on breeding and breeding work and ensuring a stable and full-fledged feed base will contribute to the growth of the production of high-quality, competitive commodity products of sheep breeding. The steady high demand of part of the population for environmentally friendly and high-quality lamb and mutton, both domestic and abroad, will ensure the effective functioning of sheep meat production and make it economically profitable for the investment. The startup of halal and kosher production for export holds promise.

Of course, the dynamic development of pig and poultry production in the country has set the growth rate of processing industry businesses based on the production of meat and meat products, which led to the improved capability of providing the population with food and also to the growth of export potential. However, despite several positive trends that have emerged in the meat sub-sector, in general, the economic situation is quite unstable. The low investment climate in farms does not allow using the achievements of scientific and technical progress with the transition to its subsequent innovative development everywhere. At the same time, today, large modern enterprises of the meat industry with a powerful specialized production potential, equipped with highly efficient equipment, are idle due to the lack of raw materials. In this regard, it is quite apparent that the effective functioning of the meat sub-industry directly depends on the level of development of livestock production, which, in turn, is determined by the level of production and the state of the feed base, the presence of full-fledged feed. The field feed production remains the main source of feed in the country. In 2017, compared with 1990 (Table 2), the area under fodder crops in the country decreased by 28, 218 hectares, while their most significant decrease—by 15,474 ha occurred during the period 1991–2000, and, as a result, led to a sharp decrease in the gross yield of these feed crops. The feed grain is an important basis of the fodder base in animal husbandry. Oat is one of the main representatives of grain crops; its grain is an indispensable concentrated feed for farm animals. However, over the past thirty years in the country, the area under this

Table 2 The sown area under fodder crops, thousand ha

Names of forage crops	Years						2017 in % to 1990
	1990	2000	2005	2010	2015	2017	
Forage crops	44,560	29,086	22,065	18,046	16,993	16,342	36.7
Perennial herbs	18,287	18,184	14,901	10,795	9957	9804	53.6
Annual herbs	12,612	5981	5001	4680	4536	4107	32.6
Silage corn, green feed and haylage	10,089	3670	1575	1503	1382	1365	13.5
Fodder root crops	732	165	104	41	26	20	2.7

Source Federal State Statistics Service [4], calculated by the author fodder crop has decreased by 3.4 times (Table 3). A similar situation is observed in barley crops: a reduction of 1.9 times. Cereal legumes are cultivated to produce grain with a high protein content, which is of great feed value. They have not only high feed value, but also improve the use of animal feed of other low-protein crops. The most common leguminous crop for animal feed is peas.

Though, the crops of leguminous crops, peas decreased in 2016–2017 to the levels of 1986–1990, to 1973 and 2027 thousand ha. However, in recent years, sown areas under peas are expanding. The changes in the structure of grain crops in the country had a significant impact on the state of the forage base of livestock. A significant reduction in sown areas under grain crops, while at the same time, the expansion of the country's grain wedge in the structure of food crops, especially wheat, led to the use of its expensive grain for fodder purposes.

Currently, an increase in the production of feed grain is possible by increasing the yield and expanding the sown area of forage crops. The improvement of the quality of herbal feed is achieved by eliminating the loss of its nutritional value during harvesting and storage. Particular attention is paid to improving the quality of feed by eliminating the deficiency of digestible protein, the lack of which significantly increases the consumption of feed resources. An increase in the production of high-value fodder protein can be achieved: firstly, by increasing the specific gravity in the structure of the sown areas of the country with protein-rich cereals, in particular, peas; secondly, an increase in the proportion of legumes in the crops of perennial and annual herbs; thirdly, by increasing the level of intensification of cultivation of forage crops based on their selection in the direction of increasing protein. Strengthening the forage base of animal husbandry will ensure increased meat production and will reduce feed consumption per unit of output.

Given the close and inextricable link between crop production and animal husbandry through the feed production system, it can be stated that the effective functioning of animal husbandry depends on its distribution throughout the country, taking into account the calculation of animal feed requirements. At the same time, an important point is the determination of the sources of feed and their appropriate quality and quantity in order to meet the needs of the animals fully. The rational distribution of livestock breeding involves the design basis for the full development cycle of all related sub-sectors of this production process. The key results of assessing the rational distribution of livestock production are the productivity of farm animals and herd reproduction rates, taking into account genetic potential. Productivity directly depends on the choice of the breed of animals, the level of feeding, the cost of electricity; water; and fuel, the design system for keeping animals, veterinary services, the degree of mechanization of production processes, and the use of intensive technologies. The results of calculations of the herd turnover and the output of gross and marketable livestock products give us an idea about this production's level of distribution. The growth of livestock production, in turn, contributes to an increase in the need for crop production used for animal feed [8].

The country's territory has colossal grassland and cheap and reproducible resources that constitute the main feed for specific animal species, but this potential of the country is practically not realized. In current market conditions, the location

Table 3 The sown area of individual grain and leguminous crops, thousand ha

Types of feed grain	Years							2016–2017 in % to 1986–1990
	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	2016–2017	
Barley	15,405	15,148	10,925	9937	9080	8787	8166	53.0
Oats	9834	8447	5685	3956	3392	3191	2874	29.2
Legumes including peas	3960	2243	1189	1181	1139	1711	1987	50.2
	3227	1865	823	756	797	1084	1200	37.2

Source Federal State Statistics Service [4], calculated by the author of animal husbandry practice should be based on the maximum use of climatic and biological resources while taking into account the environmental component. The natural diversity of the vast territory of the country is the main advantage that allows creating landscape-differentiated varieties and technologies that ensure the efficient and sustainable production of final agricultural products. It is also important to understand that feed production should be considered an essential factor in optimizing the degraded agricultural lands and disturbed agro landscapes of the country. The significant phytomeliorative role of the perennial grasses on arable land, hayfields, and pastures contributes to the elimination of destructive processes, reduces erosion, and increases soil fertility and productivity of subsequent crops [8]. Fodder production in Russia should be adapted to the natural conditions of individual regions and differentiated by farms with varying degrees of livestock intensification. Since feed constitutes more than 50% in the structure of the production costs of livestock products, cost reduction strategies should be followed along the way in order to increase the profitability of livestock production. The pasture keeping of animals has a tremendous resource potential. For an increased reproduction of cattle and the restoration of the livestock of sheep and beef cattle, the leading role belongs to improved productive pastures. The intensification of regional field feed production systems, including the expansion of the sown area, improvement of the species and varietal composition of crops, development of resource-saving technologies for their cultivation, and rational use of raw materials, contributes to an increase in gross feed production.

The sustainable development of the meat industry is possible, only based on the territorial-sectoral division of labor in animal husbandry using the achievements of scientific and technological progress, which are based on innovative processes. Digitalization, including the use of sensors and sensory components, as well as other innovations, will lead to the best results on the way to reducing the cost of final meat products, only when rationally placing livestock in the national territory with the creation of specialized zones and the concentration of certain types of animal stocks, taking into account the location of high-grade feed sources. The creation of agricultural enterprises, on the basis of the territorial and sectoral division of labor, using the information and cognitive technologies and robotics, will allow the formation of a responsible industry of highly efficient production and processing of agricultural raw materials [5].

For the widespread introduction of breeding, genetics, industrial, technological, organizational, and managerial innovations, the appropriate state policy is a key point in the effective development of rational distribution and deepening of specialization in animal husbandry. In this regard, it is necessary: firstly, to have a developed legislative framework governing innovation; secondly, the presence of highly qualified specialists in this field; thirdly, identify targeted sources of funding; fourthly, the existence of a close relationship between scientific organizations and agricultural producers, which will ensure the sustainable, innovative development of the meat subsector as a whole.

4 Discussion

The issues of transitioning to an innovative model for the development of Russian agriculture on the basis of a territorial-sectoral division of labor, taking into account the maximum use of the potential opportunities of each individual region, ensuring sustainable production and high quality of final commodity products, and its competitiveness in world markets are actively discussed in the works of Altukhov [1, 2], Nechaev [2], Sandu [7], and others.

It can be stated that the conducted scientific study made it possible to summarize part of the empirical data on the prospects for the formation and development of rational and effective distribution of livestock production throughout the country to ensure the internal needs of the population and the possibilities of increasing export potential. The strategic role of the formation of specialized zones with the concentration of certain types of animals is not only to increase the volume of high quality, marketable products and their competitive exports but is also the fundamental basis for the development of the territory.

5 Conclusion

The key indicators of the effective functioning of the meat sub-sector in the country are the level of development of livestock and the state of its feed base. It is the state of the raw material base that determines the sustainability of the production of meat industry enterprises, economic efficiency, and the quality of meat and meat products. An increase in the yield of forage crops, especially with a high content of digestible protein, will provide rational and adequate nutrition for livestock and poultry. In current market conditions, the competitive functioning of the meat industry in the country can be achieved by mobilizing its resources with a high level of its production potential, based on the use of the achievements of scientific and technological progress. Satisfying the needs of the population in high-quality meat products and increasing the export of certain types of meat and meat products are possible with the sustainable and dynamic development of the meat sub-sector, based on the widespread introduction of selection, genetic, production, and technological innovations. The use of intensive resource-saving technologies should be considered as one of the critical factors for increasing the commodity resources of meat. The specialization and concentration of livestock are the least expensive and most economically feasible direction of the development of the sub-sector. Organizational, managerial, and investment support of the state will become an incentive to increase innovative activity in the meat sub-sector, ensure the production efficiency of meat industry enterprises, and increase competitive meat products in the domestic and world markets. The production of organic meat products should be considered as the most promising, high-tech, and largely innovative direction in the production of meat, which allows increasing income from its export.

References

1. Altukhov, A.I.: Methodology for improving the territorial and sectoral division of labor in the country's agro-industrial production. In: Altukhov, A.I. (ed.) Prospects for the development of agriculture of the Russian Federation: innovative-technological parameters, forms of a territorial organization, pp. 18–25. AzovPrint, Rostov-on-Don (2016)
2. Altukhov, A.I., Nechaev, V.I.: Economic problems of innovative development of the grain product sub-complex of Russia. Publisher Nasirddinova V.V, Moscow (2015)
3. Bogoviz, A.V.: The new paradigm of innovational development of Russia's AIC in the conditions of the EAEU. Lect. Notes Netw. Syst. **73**, 193–202 (2020)
4. Federal State Statistics Service: Statistical database. Retrieved from https://www.gks.ru (2019)
5. Government of the Russian Federation: Program "Digital Economy of the Russian Federation", 28 July 2017, No. 1632-r. Retrieved from https://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf (2017)
6. Russian Federation: Federal Law "On Organic Products and on Amending Certain Legislative Acts of the Russian Federation", 3 Aug 2018, N 280-FZ (2018)
7. Sandu, I.S.: Priority areas for the development of the agro-industrial complex of Russia. In: Tkachev, A.N. (ed.) Innovation and investment support of agribusiness as a growth factor, pp. 365–381. TekhnologiyaTSD, Moscow (2018)
8. Silaeva, L.P., Solntseva, O.V.: Guidelines for predicting the production and consumption of major agricultural products, raw materials, and food. In: Paptsov, A.G. (ed.) Modernization and innovation—strategic directions for the development of agriculture, pp. 372–374. Scientific Information Production and Commercial Center Voskhod-A, Moscow (2010)

Competitiveness Management of Russian Innovation Entrepreneurship

Sergey V. Laptev, Faina V. Filina, and Dmitriy V. Timohin

Abstract The relevance of the study lies in the fact that the lag of Russian innovative entrepreneurship from advanced countries in terms of competitiveness is intensified. The tools for overcoming this lag are not justified in theory and not clearly defined in practice. The paper identifies the main constraints to the development of innovative entrepreneurship in Russia: the slowdown and lack of development of innovative processes; a relatively low patent activity of entrepreneurs; a low participation of corporations in innovation financing; a lack of funding for basic research; and a small number of organizations that can integrate innovative processes. Practical recommendations on increasing the competitiveness of national innovative entrepreneurship are defined. The analysis of the impact of changes of technological cycle on innovative systems of both developed and developing countries is carried out. Possible options for extrapolating and adapting the experience of the positive use of this influence in relation to Russia are indicated. The authors argue that in order to implement the strategy for increasing the competitiveness of the Russian innovative entrepreneurship, it is necessary to use both market methods and measures of state regulation of the economy as efficiently as possible. Moreover, all factors contributing to the development of innovative entrepreneurship in Russia should be used comprehensively, all elements of the innovation system should be formed.

Keywords Competitiveness · Innovative entrepreneurship · Market · Self-organization of entrepreneurs · State regulation of the economy

S. V. Laptev
Financial University Under the Government of the Russian Federation, Moscow, Russia

Plekhanov Russian University of Economics, Moscow, Russia

F. V. Filina (✉)
Moscow International University, Moscow, Russia
e-mail: nauka-ags@mail.ru

D. V. Timohin
Moscow State University of Humanities and Economics, Moscow, Russia

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_35

1 Introduction

The main indicators of innovation in Russia in recent years have not significantly increased. Thus, the share of innovative products in the total output in 2013–2014 amounted to 8–9%, in 2017—7.2% [9], in the leading countries it equals to about 15% [5], that is, this share has even slightly decreased.

The share of high-tech products in total exports from 2013 to 2017 changed from 10.2 to 13.7%—the growth rate is lower than that of most innovatively advanced economies. There is no complexity in the organization of innovation: there are gaps in the formation of the infrastructure of innovation, the commercialization of innovations is poorly developed, the number of registered international patents is significantly behind the leading countries, corporate financing of innovation is much less than state funding, and there is a lack of funding for basic research.

In Russia, there are few integrator companies capable of comprehensively organizing innovative processes at all the main stages, so that even innovative business projects created in Russia often do not find application in leaving the country. But the modernization of the economy should be carried out in the period until 2030–2040, as during this period, the change of leaders of the global innovation sphere for the coming century is forecasted [7].

2 Materials and Methods

The paper is written in the form of a comparative characteristic of the organization of full-cycle innovation processes in Russia and the countries leading in the generation of innovations and the most important categories of innovative products. The trends in the development of innovation markets are identified, as well as niches that are promising from the point of view of their development by Russian innovators. Based on the use of economic and mathematical research methods, effective directions for the development of national innovation systems have been identified. Russian materials, international statistics on innovation, analytical reports, and articles about the problems of developing innovative entrepreneurship were used.

3 Results

It was revealed that the main reason for Russia's growing lag in innovation is the current model of the Russian economy. The revenues from commodity exports fill the budget and reserves, providing social benefits. The balance "in one form or another is redistributed between state and non-state companies. These funds, again, in various ways are either sent outside of Russia, or saved in the form of 'conditionally foreign capital.' This capital comes to Russia as a source of investment." [2]. The economic model works on the redistribution of generated incomes, and not on their increase, nor on the development of production and innovation. Entrepreneurs are more interested in rent-seeking, rather than entrepreneurship and innovation.

Integration into global production chains in the Russian economy is justified in terms of the payback indicators of innovative companies already operating in the domestic markets (Fig. 1).

The EBIT profitability of innovative industries in Russia, allocated as part of the Russian industry classification of economic activities, is at least 6%, which is 2 times the average value in Russia [10]. At the same time, profitability in the raw-materials industries, in which a substantial part of the Russian economy's revenues is formed, is significantly higher than in the areas of innovation. The level of development of innovative activity in commodity sectors is lower than the average in the entire economy. Thus, Russian private capital in the field of innovation is bad, and the financing of innovation is dominated by the state.

There is a significant lag in key applied research in Russia, where private business dominates in other countries, which makes it possible for key manufacturers to lose competitiveness [3]. The state dominates the financing of innovation activities. It is engaged in the redistribution of created incomes and is not engaged in the systemic creation of conditions for the development of innovative activity. The state is not effective in forecasting innovation. In particular, "the analytical capabilities of 'Forecast-2030' not only do not allow us to fix the priorities of scientific and technological development, but also adequately assess the competitive capabilities of Russia in the selected scientific and technological areas" [4]. The state, as a key institution of the market economy, has not yet reconsidered its functional responsibilities, so the conditions for the development of innovative activity are not formed comprehensively.

The development of nanotechnology is a promising direction for the development of the innovative and technological basis of the national economy—within the framework of the concept of advanced development.

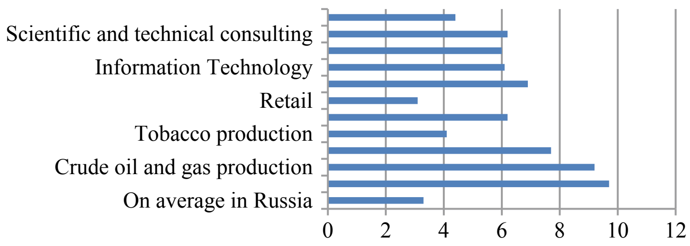

Fig. 1 Comparative characteristic of industry average profitability indicators of Ebit in Russia, percent, 2017. *Source* Compiled by the authors on the basis of [10]

Table 1 shows a backlog of Russia in the field of nanotechnology. Moreover, during 1980–2016 this lag was growing; by 2020, it will reach quadruple the size from the lack of complexity and effectiveness in innovation management. Let us consider the structure of the US budget in terms of spending on nanotechnology (Fig. 2).

The analysis of the presented information shows that in Russia, unlike the countries leading in the global economy, there is a significant bias in favor of financing applied and design research in the field of nanotechnology. To a large extent, this is done through basic research and infrastructure projects with expenses in related fields, such as medical technology. With such a structure of financing, the Russian innovation system is able to form an innovative product at the level of three to four stages of the innovation cycle. However, it will not be able to ensure the operation of the innovation system of the full cycle. At the junction of technological cycles, it seems advisable to reorient the domestic innovation system to the formation of pioneering innovative solutions, which provides the adaptation of foreign experiences and the adoption of the financing structure characteristics of the USA, China, and South Korea.

Table 1 The working topological standards for the size of objects in microelectronics in Russia and Western countries (integrated indicator)

Comparison object	1980–1990	1990–2000	2000–2008	2010–2015	2016–2020
Russia	4–2	1–0.8	0.7–0.18	0.09–0.18	<0.04
West	2–1	0.7–0.35	0.1	0.01–0.03	<0.01

Source Popov and Sukharev [8]

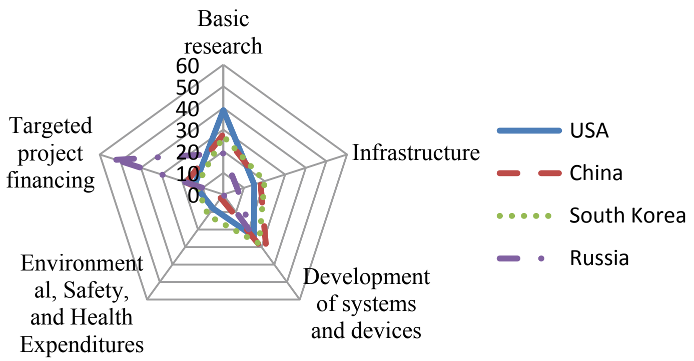

Fig. 2 Cost structure for the development of nanotechnology in some countries of the world, 2017, as a % of the total. *Source* Compiled by the authors on the basis of [1, 6, 11, 8]

4 Discussion

On the question of ways for improving the international competitiveness of the Russian economy, the main controversy is between representatives of the liberal trend and active state regulations of the economy. The representatives of liberalism advocate for the reduction of the role of the state in the economic life of the country and the use of comparative advantages in foreign trade.

The representatives of the concept of economic regulation advocate for the active use of state power in pursuing a policy of increasing the competitiveness of Russian entrepreneurs, including innovative ones, actively supporting exports, and using state power to form new competitive sectors of the innovative economy. In practice, in the field of innovative entrepreneurship success, those countries that use the maximum possible means to achieve competitive advantages regardless of the official ideology are dirigiste or liberal.

Based on the results of the study, proposals for the discussion, based on a review of foreign experience in integrating national companies into innovative processes in emerging technology markets of the 6th technological wave, are formulated (Table 2).

In order to succeed in improving the competitiveness of innovative entrepreneurship, Russia needs to use all forms of borrowing experience, starting with the simplest ones, following the example of world leaders. In financial terms, the activities and competitiveness of all organizations, especially small and medium-sized ones, are determined by access to financial resources (Whitman and Makinen 2017).

5 Conclusion

In order to increase competitiveness in the formation of an innovative model for the development of the Russian economy, it is necessary to substantially change both market and state instruments for regulating the economy by developing and adjusting the strategy for moving towards an innovative economy, using foreign experience, changing the structure of financing the innovation system, building and forming the missing links of this system, and adequately enhancing the personal responsibility of the leaders of this system for solving tasks.

Table 2 The directions for the development of competitiveness of Russian innovative production

The sphere of borrowing experience	Experience-donor country	The contents of the borrowed experience	Suggested ways for adapting experience	The impact on the of national production
Commercialization of resource potential	China	The formation of innovative productions of a full cycle	Application of the Chinese experience for the formation of the domestic REM industry	The provision of a resource base for innovative industries and integration into global value chains
Fundamental study	USA	Commercialization of discovered effects	Formation of a bank of licenses and open patents	Attraction of investments in domestic science; Increasing funding for basic research
Patent field	Japan, South Korea, Singapore	Advanced development of the innovation sector on the basis of scientific and technological progress of the 5th technological wave	Formation of a network of research institutes working at the points of growth of modern science on the basis of attracting foreign capital under state financing	Ensuring the technological linkage of innovative production of the 6th technological structure to Russian basic patents

References

1. European Commission: Horizon 2020—Work Programme 2018–2020 Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing. European Commission, Strasburg, France (2017)
2. Genkin, A.S., Nikulin, S.S., Frumkin, K.G. (eds.): Invest Foresight: Startups, Technologies, Investments. Publishing Solutions, Moscow, Russia (2018)
3. Khmeleva, G.A., Tyukavkin, N.M., Sviridova, S.V., Chertopyatov, D.A.: Cluster development of the region based on innovation under the conditions of sanctions. Econ. Soc. Changes Factors Trends Forecast **5**, 83–98 (2018)
4. Kurakova, N.G., Zinov, V.G., Tsvetkova, L.A., Eremenko, O.A., Komarova, A.V., Komarov, V.M., Sorokina, A.V., Pavlov, P.N., Katsyubinsky, V.A.: National Science and Technology Policy of "Rapid Response": Recommendations for Russia: Analytical Report. Delo, Moscow, Russia (2014)
5. Ministry of Economic Development of the Russian Federation: National report on innovation in Russia for 2015. Russia, Moscow (2015)
6. Ministry of Education and Science: Long-term forecast of scientific and technological development of the Russian Federation until 2030. Retrieved from https://prognoz2030.hse.ru (2013)
7. OECD: OECD Digital Economy Outlook. OECD Publishing, Paris, France (2017). https://doi.org/10.1787/9789264276284-en
8. Popov, E.S., Sukharev, O.S.: Moving towards a digital economy: the impact of technological factors. Econ. Taxes Law **1**, 26–35 (2018)
9. Rosstat: Science and innovation. Retrieved from https://wwwgks.ru (n.d.)
10. The return on sales for EBIT by industries (kinds of activity). Retrieved from https://www.testfirm.ru/finfactor/ros/ (2019)
11. Whitman, L.J., Makinen, A.: The national nanotechnology initiative. Supplement to the President's 2018 Budget. Subcommittee on Nanoscale Science, Engineering, and Technology Committee on Technology National Science and Technology Council (2017)

The Conceptual Model of Innovative Development of Industrial Gardening

Andrey A. Polukhin, Sergey D. Knyazev, and Ivan A. Efremov

Abstract In Russia, there is a significant problem of ensuring food security and import substitution in the market of horticultural products. Practical suggestions for improving the innovation process in horticulture regarding enhancing the activation of the macroeconomic conditions for its provision can be used by state and economic management bodies with a view to the overall qualitative transformation of agriculture on the basis of its consistent intensification. The features of the innovative development of horticulture are determined by the general specifics of farming in this vital branch of agriculture, associated with the high capital intensity of production, the unproductive period before many horticultural crops come into fruition, therefore, the investment payback periods, the organization of the technological process, etc. In the approach to new scientific and technical developments, the development of innovations in the production cycle of agricultural enterprises, it is important to consider that perennial plantations, being the main means of production in agriculture, have significant spatial-attributive differentiation (territorial, varietal, age, and also have different cultures, long periods of economic use). A characteristic feature of orchards and berry gardens is that the land occupied under them cannot be used for other purposes (except decorative gardening), except for the production of certain types of products, for many years. Only their innovative renewal is capable of ensuring the efficient use of other fixed assets and working capital of horticulture, which determines their decisive role in highly productive and efficient industry management. The conceptual model of innovative development provides for the development of an innovative gardening infrastructure in the form of the creation of a selection

A. A. Polukhin (✉)
Federal Research Center of Agrarian Economy and Social Development of Rural Areas, Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: aap.market@vniiesh.ru

S. D. Knyazev
Russian Research Institute of Fruit Crop Breeding (VNIISPK), Zhilina, Russia
e-mail: info@vniispk.ru

I. A. Efremov
Eurasian Open Institute, Moscow, Russia
e-mail: efremov-iv@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_36

genetic center and a reference center as a scientific base and an innovation transfer center on the basis of research institutes. The innovative vector of industry development in Russia will make it possible to adequately fill the need for horticultural products, ensure the growth of crop production exports and the development of the agricultural sector as a whole.

Keywords Industrial gardening · Innovative development · Agricultural economy · Food security of the Russian Federation

1 Introduction

The current economic state of gardening in Russia is characterized by significant signs of a protracted systemic crisis. The most pronounced of these signs are technological backwardness, extensive nature, low production efficiency as a result of the general qualitative imperfection of the resource potential of the industry, and the degradation of its individual elements, primarily scientific and personnel support [1].

Industrial horticulture is the cultivation of perennial crops (fruit, berries) based on the systematic use of means of production with a level of efficiency that ensures an expanded reproduction of products, plantings, and the environment [2].

Gardening is unique in its versatility sphere of human life, a priority branch of the agro-industrial complex, whose main products are fruits, berries, nuts, tea, and their processed products. The unbalanced consumption of horticultural products that contain vitamins, organic acids, and other substances necessary for humans leads to disruptions of vital processes in the body. This direct consequence gives a reason to classify horticultural products among those that determine the physiological basis for the health of the country's population. Its maintenance and preservation are a priority for any state. This implies the direct interest and responsibility of the government for the state and development of gardening. Unfortunately, at present, the problems of fruit and berry production remain in the background, which was not observed either in pre-revolutionary Russia or even in certain periods of socialist "transformations" in agriculture. Food imports, which share in its total consumption, is approximately 37%, and for horticultural products it reached almost 60%. With a minimum required production volume of 8 million tons, 2.95 million tons were received in 2017.

According to various estimates, a Russian consumes 34–53 kg of fruits and berries per year, with a recommended rate of about 100 kg per year. The average American consumes 126 kg, Australian 135 kg, Chinese 50 kg. In 2010–2017, the average Russian family spent about 12% of the family budget on fruits.

2 Materials and Methods

In order to develop a conceptual model of the innovative development of gardening, a comprehensive analysis of the existing problems associated with the formation of infrastructure to provide a scientifically-based production of fruit and berry products is necessary. The information base of the study was: departmental statistical data of the Unified Interdepartmental Information and Statistical System ("EMISS," [3]), reports of the Federal State Statistics Service.

According to the available data, the task of the study is to formulate a model project for creating innovative infrastructure for the development of horticulture on a scientific basis.

The key issue considered in the study is the possibility of organizing the development of intensive gardening on a scientific basis, with the involvement of the intellectual potential of scientists. This problem is considered both from the point of view of supply and demand for horticultural products and from the point of view of supply and demand for varieties and scientific achievements in terms of horticultural technologies.

3 Results

The President of the Russian Federation instructed the Government to develop a set of measures aimed at creating and implementing competitive domestic technologies until 2026, ensuring the production of original and elite seeds of agricultural plants and breeding products (materials) in the areas of domestic crop production and pedigree livestock farming, which are now highly dependent on foreign supplies [4, 5].

The formation of an effective fruit and berry sector creates conditions for ensuring food security in this segment on the basis of import substitution. The level of provision of the population of Russia with fruit and berry products produced in the Russian Federation is presented in Table 1 [6, 7].

Federal Law 227-FZ "On the Consumer Basket in the Russian Federation" defines the consumption rate of fresh fruit for the able-bodied population of Russia as 60 kg/year per person. In fact, consumption in 2016 amounted to 23 kg/year. The consumer basket of children, according to the same law, is 118.1 kg/year of fruit per person, in fact—51.9 kg/year. The consumer basket of a retired person is 45.0 kg/year, in fact—22.0 kg/year. The need for healthy food standards in 2016 amounted to 14.7 million tons of fresh fruits, and current consumption is 5.0 million tons.

A significant share of the fruit market is formed by foreign suppliers, so the volume of foreign deliveries in 2017 increased by 14.9% compared with the same period in 2016. The main suppliers of pomaceous fruits are countries such as China, Serbia, Argentina, and Moldova. Citrus fruits are imported from Turkey, China, and Morocco (Table 2).

Table 1 The provision of fruit and berry products in Russia in 2017, thousand tons

Subjects of Russia	Population as of 2017, million people	Production in 2017 (farms of all categories)	Security, %
Russia	146.8	2946.3	20.1
Southern FD	16.4	941.4	57.3
North Caucasian FD	9.8	478.7	49.0
Volga FD	29.6	532.5	18.0
Central FD	39.2	538.9	13.7
Northwest FD	12.4	106.7	7.7
Ural FD	12.4	149.0	12.1
Siberian FD	19.4	155.0	8.0
Far Eastern FD	6.2	44.1	7.1

Source Department of Plant Production, Mechanization, Chemicalization, and Plant Protection of the Ministry of Agriculture of Russia

Table 2 The import of the main categories of fruits and berries into Russia

Indicators	2015		2016		2017	
	Quantity, thousand tons	Price, $/t	Quantity, thousand tons	Price, $/t	Quantity, thousand tons	Price, $/t
Pomaceous fruits	1158.4	469.9	649.0	592.5	686.1	629.6
Stone fruits	377.8	734.5	355.1	779.7	419.0	946.5
Bananas	1226.6	741.8	988.8	737.9	1137.0	738.4
Citrus fruits	1560.0	774.4	805.3	788.2	847.8	782.7
Other fruits	294.7	1009.6	118.2	1137.2	138.1	1165.9

Source Compiled by the authors, according to the Federal Customs Service of Russia

The Ministry of Agriculture of Russia has developed a strategy for the development of industrial horticulture. On its basis, the "State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets for 2013–2020 No. 717-r" has been developed. It includes the subprograms, which state the main activities for the development of the fruit and berry subcomplex. The volumes of state support for gardening are presented in Table 3.

The development of domestic gardening is dependent on the availability of high-grade, adapted, certified planting material.

Currently, there is a tendency to increase the varieties of cultivated fruit crops (Table 4)—an increase of 24.5% over 9 years. Given the order and timing of certification for new varieties, this growth seems substantial. However, in the categories of

Table 3 The level of state support for gardening, thousand rubles in the framework of the state program for 2013–2017

Directions of state support	2013	2014	2015	2016	2017	Total volume
The planting and care of gardens	427.2	371.0	2058.1	2206.5	3306.0	8368.8
The uprooting of old gardens	36.7	54.4	86.1	87.8	0	265

Source Department of Plant Production, Mechanization, Chemicalization, and Plant Protection of the Ministry of Agriculture of Russia

Table 4 Data from the State Register for the assortment of fruit and berry crops approved for use in 2018

Crops	The number of varieties, pcs		2018 in % to 2009
	2009	2018	
Pomaceous fruits	490	611	124.7
Stone fruits	337	481	142.7
Berries	640	735	114.8
Total fruits and berries	1467	1827	124.5

Source Compiled by the authors on the basis of data from the FSBI "State Commission"

crops, the growth rate varies significantly: pomaceous fruits—24.7%, stone fruits—42.7%, berries—14.8%. But these differences can be explained by the structural species characteristics of fruit and berry crops.

In 2017, fruit-and-berry plantations were laid in Russia on a total area of 15.2 thousand ha, of which 11 thousand ha (72.4%) were the intensive orchard. About 34 million planting material was planted, of which almost 19% was foreign origin.

It is possible to provide the industry with high-quality, adapted planting material only by creating a network of basic, certified nurseries in each agroclimatic zone in Russia with grow-zoned planting material of higher reproductions from uterine and basic nurseries at scientific institutions.

One of the important factors hindering their introduction into production is the state of the nursery. Low-quality planting material that does not meet intensive gardening requirements, as well as compliance with legislation in the field of selection and seed production are the main problems for the vast majority of nursery farms. In order to meet the need for planting material in the country, experts agree that there should be about 10,000 nurseries growing planting material for a particular gardening zone. In Russia, only 184 nursery farms currently produce planting material that meets the standard, mostly concentrated in the Southern Federal District. The deficit is covered by the import of planting material; its share is increasing annually. Imported planting material can be successfully used in the southern regions of the country with a relatively mild climate, while in other areas, its use increases producer risk due to its low adaptability potential (Table 5).

Table 5 Sales of fruits and berries by industrial enterprises through distribution channels

Years	Crops	Total		Distribution channels					
				Processing enterprises		Markets, shops, tents, kiosks		As a payroll	
		th. tons	P thousand	th. tons	P thousand	th. tons	P thousand	th. tons	P thousand
2013	Pomaceous fruits	23.3	608.6	22.4	593.0	1.0	35.8	0.6	10.9
	Stone fruits	418.3	5380.5	406.5	5229.1	10.7	142.4	8.1	115.7
	Berries	3.2	323.6	2.9	299.0	0.4	30.9	0.4	24.5
2017	Pomaceous fruits	23.9	1196.7	20.9	1156.3	2.4	118.0	0.6	33.0
	Stone fruits	430.3	10,980.6	420.5	10,740.0	26.7	545.2	2.1	57.5
	Berries	3.3	495.3	3.2	484.8	0.7	85.9	0.09	10.5

Source Compiled by the authors based on data from the Federal State Statistics Service

Table 6 Area under cultivation of fruit crops in the Russian Federation, thousand ha

Indicators	2011	2012	2013	2014	2015	2016	2017
Total area	514.8	507.4	502.2	513.6	511.6	517.0	516.8
Area at bearing age	421.9	410.0	406.1	416.4	411.0	409.5	404.6
Pomaceous fruits	196.2	192.8	189.4	192.5	186.9	184.4	181.0
Stone fruits	101.3	100.4	99.6	104.5	104.6	105.7	105.3
Berries	117.9	111.3	111.2	112.4	112.6	112.7	111.4

Source Compiled by the authors based on data from the Federal State Statistics Service

In this regard, the creation of breeding centers in areas with high demand and a high potential for the development of gardening is of particular relevance. The main fruit and berry regions of the Russian Federation (RF) are: Central Federal District (CFD) with a total area of 145.7 thousand ha (corresponding to 28.2% of the entire fruit and berry plantation territory); Southern Federal District (SFD) is in second place with a total area of 108.3 thousand ha (20.9%); and the Volga Federal District (VFD) is in third place with 86.0 thousand ha (16.6%). The North Caucasus Federal District (NCFD) is in fourth place with a total area of 63.6 thousand ha (12.3%). More than 75% of the fruit and berry products of the Russian Federation are grown in these districts; this is justified by the natural and climatic characteristics of the regions (Table 6).

In the Central Federal District, it is advisable that nurseries for the cultivation of planting material of higher reproduction be created on the basis of the Russian Research Institute for Fruit Crop Breeding, the only specialized pomological institution in the country and the originator of half of the regionalized fruit and berry crops for the central region of Russia.

The Russian Research Institute for Fruit Crop Breeding leads in the selection of apple, pear, cherry, plum, black and red currants, and gooseberries that are most popular among consumers. A solid base for breeding is the collection of the general plasma of fruit and berry crops, which has no analogs in the world. The Russian Research Institute for Fruit Crop Breeding created 187 varieties of fruit and berry crops; 133 of them are included in the State Register of Selection Achievements approved for use (Table 7). More than 30 new promising varieties of fruit and berry crops undergo state variety testing.

The Institute is a methodological center, developer, and coordinator of complex breeding programs carried out in cooperation with the National Research University of Russia and abroad. The selection and sorting of fruit and berry crops in Russia and in the post-Soviet space are carried out according to the methodological developments of The Institute's staff.

The Institute has the necessary resources for creating nurseries for the production of planting material for higher reproductions. This is 400 ha of experimental production plantings, including about 200 ha of experimental breeding plots (Table 8). The nursery division produces a wide range of high-quality planting material for fruit and berry crops.

Table 7 Breeding achievements of the Russian Research Institute for Fruit Crop Breeding

Indicators	Quantity, units
Created Crops	187
Included in the state registry (zoned)	133
Incl.	
Apple	56
Black currant	14
Cherry	21
Red currant	12
Cherry Roots	8
Pear	8
Plum	7
Sweet cherry	4
Apricot	2
White currant	1

Source Compiled by the authors based on data from the Federal State Statistics Service

Table 8 Research and production areas of the Russian Research Institute for Fruit Crop Breeding

	Area, ha
Total area	427.6
Perennial plantings	322
Incl.:	
To be uprooted	185.9
Fruit bearing	47.5
New plantings	89.3
Incl.:	
Super intensive type	3.5
Intensive type	82.3
Traditional technologies	3.5
Berry-bearing plant	81.7
Nursery	23.2

Source Compiled by the authors based on data from the Federal State Statistics Service

At the Russian Research Institute for Fruit Crop Breeding, studies that have no analogs in complexity are carried out. They include studies on genotyping; DNA labeling; genomic editing; microclonal propagation; cytological, biochemical, physiological, and agrotechnical studies; and the study of the suitability of varieties for long-term storage and species processing. Elements of varietal technologies for growing intensive and superintensive gardens are being developed.

The Russian Research Institute for Fruit Crop Breeding is the main supplier of varieties for central Russia. About half of the assortment of apple, cherry, apricot, and red currant, a third of the assortment of black currant, 80% of plum varieties, and 100% of stocks for sweet cherries were included in the state register of selection achievements allowed for use in the Russian Federation for the Central Black Earth Region. These are the breeding achievements of the Russian Research Institute for Fruit Crop Breeding.

New varieties introduced at the Institute fully correspond to the natural and climatic conditions of most of Central Russia and can successfully compete not only with domestic varieties but also with foreign ones since they have a limiting sign for our zone—high winter hardiness and frost resistance.

To date, the Institute has developed 30 varieties of apples that are immune to diseases and pests. Twenty of them (Imrus, Bolotovskoye, Veniaminovskoye, Kandil' orlovskiy, Svezhest, Rozhdestvenskoye, and others) are widely used in the Central Black Earth Region. Immune varieties can significantly reduce the use of chemical protective equipment in gardens, thereby improving the environmental situation.

For the first time, scholars at the Russian Research Institute for Fruit Crop Breeding have created triploid apple varieties that have high fruiting stability (without periodicity), adaptive ability, and high marketability. Twelve of them are already successfully used in a number of regions of Central Russia (Yablochnyy Spas, Avgusta, Darena, Maslovskoye, Rozhdestvenskoye, and others). Moreover, such varieties as Zhilinskoye, Maslovskoye, Yubilyar, Yablochnyy Spas, and Alexander Boyko combine triploidy with scab immunity.

The researches on the creation of column-shaped varieties of apple trees are actively conducted. The varieties of Poeziya, Priokskoye, Sozvezdiye, Yeseniya, and Zelenyy Shum combine column-shaped with immunity to scab and excellent taste of fruits.

The Institute grew winter-hardy, low-growing varieties of pears (Tyutchevskaya, Muratovskaya, Pamyat' Parshina, Yeseninskaya, Lira, Orlovskaya letnyaya, Orlovskaya krasavitsa), which are used in intensive gardens of the Central region of Russia. This allows us to transfer pear cultivation in central Russia to a fundamentally new level. On the basis of quince, small rootstocks compatible with cultivars of pears are selected. Their introduction will make it possible to transfer the culture to an industrial basis.

Resistant to the most harmful pathogens—coccomycosis and moniliosis—productive varieties of cherries with high taste and technological qualities, created at the Institute, are characterized by regular productivity. The most widespread are Turgenevka, Shokoladnitsa, Putinka, Kapel'ka, Businka, Novella, and Podarok.

The clonal rootstocks of cherries created at the institute are characterized by high rooting and resistance to fungal diseases.

Kunach and Orlovchanin varieties of apricots from the Russian Research Institute for Fruit Crop Breeding are superior in winter hardiness to the majority of the used varieties of this crop in the Central region.

For the first time in Russia, the Institute's breeders obtained varieties of black currant, combining, along with large-fruited, self-fertility, immunity to powdery mildew, and bud mites (Kipiana, Iskusheniye, and Gratsiya). Nowadays, more than 20 varieties of blackcurrant suitable for mechanized harvesting have been created.

The Institute's recurrent varieties are distinguished by long-grains, many with good taste, suitable for mechanized harvesting, which allows industrial-scale cultivation. Also, many varieties are characterized by a high pectin content, allowing high-quality products without artificial thickeners (Valentinovka, Niva, Osipovskaya, Asya, Dar Orla, Asora, Dana, Ogonek, Podarok Leta).

The nursery of the Institute annually produces about 200 thousand pieces of planting material of fruit and berry crops.

Based on the foregoing, it is advisable to organize, on the basis of the Russian Research Institute for Fruit Crop Breeding, an interregional selection and genetic center for fruit and berry crops. This center can be the basis for the creation of the interregional reference center of the Russian Research Institute for Fruit Crop Breeding.

The Russian Research Institute for Fruit Crop Breeding prerequisites for creating a breeding and genetic center for fruit and berry crops are due to the competitive advantages of the Oryol region, which occupies a favorable geographical position, provided with labor, intellectual and land resources, as well as favorable climatic conditions for growing planting material for fruit and berry crops adapted to a wide range of climatic conditions in central Russia.

The modernization and strengthening of the scientific and production base, combined with the high intellectual potential of the Russian Research Institute for Fruit Crop Breeding, in the shortest possible time will create a solid foundation for the domestic nursery and horticulture to reach world standards and will achieve the goals set in the development strategy of the agricultural sector of the Russian Federation.

4 Discussion

1. The creation of a breeding and genetic center for fruit and berry crops on the basis of the Russian Research Institute for Fruit Crop Breeding will ensure the effectiveness of scientific research on the creation of new varieties of fruit and berry crops, the development of varietal cultivation technologies and their introduction into production, the production of high-quality planting material, strengthening the positions of domestic selection and gardening, and increasing the investment attractiveness of gardening.
2. It will provide a basis for the organization on the basis of interregional breeding and a genetic center for fruit and berry crops of the Interregional Reference Centre (IRC) of the Russian Research Institute for Fruit Crop Breeding. It will form an inter-regional market of a landing material of fruit and berry crops, ensure the scaling and replication of a successful experience in the production and sale of planting material via a network selection of production sites, and provide training of highly qualified personnel for the horticulture industry and

comprehensive support of nursery and horticulture. The tasks of the reference center are the following:

(a) the coordination of breeding work on fruit and berry crops in central Russia and the Middle Volga region;
(b) the certification and control of varietal purity and quality of planting material;
(c) the production and sale of planting material for fruit and berry crops of the category super-super-elite and super-elite;
(d) the creation of a network of nurseries for the production of planting stock of fruit and berry crops of higher reproductions;
(e) the organizational, consulting, technological, and marketing support of nurseries; and
(f) training for nursery and gardening workers.

3. The reconstruction, modernization, and expansion of the greenhouse complex; re-equipment of microclonal propagation laboratories; genomic editing; and genotyping, along with the creation of a pathogen diagnostics laboratory, will ensure cleanliness and quality control of planting material for higher reproductions. It will also ensure the preservation and maintenance of the genetic collection of fruit, berry, and ornamental plants in accordance with FAO standards [8].
4. The construction of a phytotron with an area of at least 500 m^2 will ensure high phytosanitary purity of the basic plants of fruit and berry crops and, as a result of the planting material produced, give an objective assessment of the adaptive potential of existing and created varieties at the early stages of the selection process, which will provide competitive advantages for varieties recommended for production.
5. The construction of a modern fruit warehouse with a storage capacity of at least 1500 tons will provide a comprehensive assessment of existing and created varieties for suitability for long-term storage, and the development of technologies for their storage.
6. The construction of an experimental workshop for processing fruits and berries will improve existing and new technologies for obtaining functional food.
7. The laying of pilot production and demonstration orchards of fruit and plantations of berry crops will ensure the introduction of new varieties and technologies.
8. The creation of basic and certified mother plants will provide the Central region of Russia with high-quality, certified planting material for laying intensive plantings.
9. The IRC, the logistics center, and the technology transfer center will increase the efficiency of the infrastructure of the interregional breeding and genetic center, as well as accelerate the introduction of new varieties and technologies in the real sector of the economy.

10. The costs of reorganizing the Russian Research Institute for Fruit Crop Breeding to the inter-regional breeding and genetic center will be returned within 10 years due to the sale of planting material of higher reproductions, the sale of newly planted experimental production, and demonstration of fruiting plantations. The expected annual yield is 2000 tons of fruits and berries. It is also expected to receive funds from the operation of the centers of collective use and technology transfer, both from consumers of their services and through grants for research. Updating fundamental and applied research programs creates the basis for the development of high technology, small, innovative enterprises.

5 Conclusion

The strategic goal is to create conditions for the development of competitive horticulture in Russia, based on the formation of an advanced scientific and production base for the creation and promotion of the latest selection achievements in fruit and berry crops.

In order to achieve the goal, it is necessary to solve a number of problems in the near future:

- to organize, on the basis of the Russian Research Institute for Fruit Crop Breeding, an interregional selection and genetic center for fruit and berry crops;
- to modernize and expand the scientific and production base for the production of planting material of fruit and berry crops of higher reproductions;
- to organize work on the basis of the Russian Research Institute for Fruit Crop Breeding of the interregional reference center, for scientific and methodological support and control of the creation of competitive varieties of fruit and berry crops, and production of planting material;
- to ensure high profitability of the functioning of the selection and genetic center for fruit and berry crops in a short time;
- to update the programs of basic and applied research, ensuring the rapid development of domestic selection and gardening.

References

1. Paramonov, P.F., Egorov, E.A., Artemova, E.I., et al.: Agri-food Market of the Region: Theory and Practice. Kuban State Agrarian University, Krasnodar, Russia (2016)
2. Egorov, E.A.: The main directions of adaptive intensification of gardening. Hortic. Viticulture **3**, 2–3 (2004)
3. Unified Interdepartmental Information and Statistical System. Retrieved from https://www.fedstat.ru/ (2019)
4. Presidium of the Council under the President of the Russian Federation for Strategic Development and National Projects: Presidium of the Council under the President of the Russian

Federation for Strategic Development and National Projects (2018). (December 24, 2018 No. 16). Moscow, Russia (2018)
5. President of the Russian Federation: On approving the doctrine of food security of the Russian Federation (January 30, 2010 No. 120). Moscow, Russia (2010)
6. The official website of the Russian Federation for posting information on bidding: Lease and sale of land. Retrieved from https://torgi.gov.ru/lotSearch1.html?bidKindId=2 (n.d.)
7. Russian Population Census—2010: Volume 1 “Population and distribution.” Retrieved from https://www.gks.ru/free_doc/new_site/perepis2010/croc/perepis_itogi1612.htm (2013)
8. FAOSTAT. Retrieved from https://www.fao.org/faostat/en/ (2019)

The Organization of Agricultural Markets as a Factor of Innovative Development in the Agricultural Economy

Sergey V. Laptev, Faina V. Filina, and Lyubov V. Degteva

Abstract The paper focuses on the study of the impact of the organization of commodity, resource, and financial markets on the innovative development of the agricultural economy. The paper is based on both statistics and research results in the field of growth sources and structural changes in agriculture. The authors argue that the two key factors (the degree of control over income and the level of competition in the sphere of economic activity) affect the rate of economic growth and the innovative activity of organizations. Moreover, the possibility of monopoly control of income and profitability creates the prerequisites for a more complete financing of innovations, at the same time reducing the motivation for this kind of activity. Moreover, the leadership in innovation in the Russian markets does not yet allow to lead in revenue and profitability. The outstripping dynamics of labor productivity in agriculture, the maintenance of innovation activity at a level no lower than in extractive industries, which are significantly better provided with financial resources, are currently associated with a high level of competition in agriculture, as well as with the dynamic increase in the role of holdings in agricultural production, in which the level of production of marketable products per employee is ten times higher than in independent agricultural organizations. In order to maintain a high level of innovative activity in agriculture, it is necessary to ensure equal conditions for competition for enterprises of all legal forms. Further increasing the role of holdings and increasing their competition with independent organizations will support the outstripping growth of labor productivity and innovative activity in agriculture.

S. V. Laptev
Financial University Under the Government of the Russian Federation, Moscow, Russia

Plekhanov Russian University of Economics, Moscow, Russia

F. V. Filina (✉)
Moscow International University, Moscow, Russia
e-mail: nauka-ags@mail.ru

L. V. Degteva
Moscow State University of Humanities and Economics, Moscow, Russia

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_37

Keywords Innovative activity · Innovation activity · Agricultural organizations · Agricultural holdings · Labor productivity · Competition · Economic growth rate

1 Introduction

The organization of markets in the study of problems of innovative development currently receives much less attention than such phenomena as government support for private investment and innovation, the volume and growth rate of innovative investments, or various indicators characterizing the intensity of innovative activities of organizations.

Meanwhile, it is the organization of commodity resources and financial markets that, to a large extent, determines the strength of motivation of economic entities to innovate, their own organizational and resource capabilities of these entities in the field of innovation. The purpose of the study is to establish the nature of the dependence of innovative activity in agriculture on various aspects of market organization in the field of this activity and to formulate proposals in the field of improving market organization to improve the dynamics of innovative processes in agriculture.

2 Materials and Methods

The study is based on a comparison of statistics from the results of Russian and international studies in the field of innovation in agriculture and on the identification of the role of individual factors in the course and results of innovation processes in agriculture.

3 Results

Russian researchers of innovation processes in the economy identified, among other features of the course of innovation processes, the following: "the lack of priorities of the most important scientific and technological areas with high industrialization potential;" "Lack of demand for breakthrough results from domestic enterprises in the industrial sector." This logically results in the fact that "Russia's 6–8 years backlog from the beginning of the development of most breakthrough areas is a critical factor in achieving technological leadership, and with it the occupation of a share of future markets" [6].

These results of an authoritative study can be interpreted as follows: In the Russian economy, a typical situation is the lack of demand for breakthrough innovations among key market players, respectively, planning for breakthrough innovations is not a decisive factor for the success of these players. This implies Russia's chronic lagging behind the key players in the global market in the field of innovation and the indecently low share of Russia in world markets in the production of innovative products.

Not the lack of resources, not the insufficient qualifications of managerial personnel, not the shortcomings in equipping the scientific and experimental base of research, namely the organization of markets in which the implementation of breakthrough innovations is not a key success factor and does not determine the winner in the markets—this is the true reason for Russia's lag in the region development of innovation processes.

To argue this conclusion, we considered the results of innovation processes in various areas of economic activity in Russia in recent years (Table 1).

According to Table 1, the number of advanced developed technologies is not directly related to the size of the industry, the number of available resources, or the financial capabilities of the industry.

Thus, despite the fact that the shares of extractive and manufacturing industries in GDP are close (12.9% and 13.7% in 2018, respectively), and the financial condition of extractive industries is much better than manufacturing, the number of new technologies developed in the extractive industries is 19.2 times less than in manufacturing. In the field of coke and petroleum products, only two new technologies have been developed. The fields of research and development and higher education developed many more new technologies than any other sector of the economy. However, their financial situation is far from consistent with their contribution to the development of the economy and innovation.

The percentage of agricultural organizations engaged in innovation is 11.5% if we summarize the shares of organizations engaged in innovation in the production of annuals, perennials, seedlings, and livestock; this exceeds the average indicator in the economy and is approximately 15–16 times higher than the level of innovation activity of organizations in extractive industries and significantly better provided with financial resources [5]. The results of the industry's innovation activity depend not only on its innovation activity but also on the industry's place in the inter-industry exchange.

The redistribution of gross added value due to unequal intersectoral exchange significantly reduces the cost results of the innovative activity of organizations. Thus, in 2017, the value of all produced innovative goods in agriculture amounted to ₽20.78 billion, and in the mining industry, it amounted to ₽224.56 billion, which is 11 times more [5].

Despite significant differences in the financial situation of individual sectors of the Russian economy, in the levels of their financial security, the level of their innovative activity may vary slightly. In particular, this applies to agriculture and extractive industries. From this, we can conclude that since the level of the provision of the financial resources of a particular industry positively influences innovation activity, the positive factor of a higher provision of extractive industries with financial resources is apparently balanced by some other negative factor. This factor is the monopoly position of the extractive industries, which provides the opportunity to receive rental income that does not depend on innovative activity. This factor sharply reduces the

Table 1 The number of advanced production technologies developed for certain types of economic activity in the Russian Federation

Indicators	Code by the Russian classifier of economic activities	2017 (pcs.)
Total, of them by type of economic activity:		1402
Mining	B	23
Manufacturing industries, of which	C	442
Food production	10	16
Wood processing and manufacture of wood and cork products	16	10
Production of paper and paper products	17	11
Production of coke and petroleum products	19	2
Production of chemicals and chemical products	20	13
Production of medicines and materials used for medical purposes	21	5
Metallurgical production	24	58
Manufacture of fabricated metal products, except machinery and equipment	25	56
Manufacture of computers, electronic and optical products	26	82
Manufacture of electrical equipment	27	26
Manufacture of other vehicles and equipment	30	34
Repair and installation of machinery and equipment	33	24
Providing electric energy, gas, and steam; air conditioning	D	31
Water supply; water disposal, organization of waste collection and disposal, pollution elimination	E	25
Computer software development, consulting services in this area and other related services	62	57
Information technology activities	63	28
Research and development	72	490

(continued)

Table 1 (continued)

Indicators	Code by the Russian classifier of economic activities	2017 (pcs.)
Higher education	85.22	280
Collective classification of economic activities—"Information and communication technology sector"	1,324,500 029.01	127
Collective classification group of types of economic activities—"Information technology branch"	1,324,500 029.11	80

Source Compiled by the authors based on data from [3]

motivation for innovation, which is associated with increased risk and often cannot provide businesses with the same income as the search and implementation of rents.

The average annual rate of growth of labor productivity in agriculture over twelve years is almost the same as in the extractive industries (Table 2).

In agriculture, the growth of labor productivity has traditionally been constrained by a lack of financial resources needed to finance investment in fixed assets [2]. The lack of financial resources is primarily caused by the inequivalent cross-industry exchange: through "price scissors", a significant part of the added value created in agriculture is redistributed in favor of allied agricultural producers. The state is not trying to maintain price proportions in the agricultural sector. Currently, only agricultural holding organizations are really opposed to inequivalent inter-sectoral exchange: holdings include, in addition to agricultural organizations, enterprises for storage, processing, transportation, and production, and, therefore, can provide the agricultural enterprises included in their composition with conditions for normal reproduction at the expense of profit in related fields of activities.

4 Discussion

Holdings provide faster growth of labor productivity in agriculture—due to investments in modern technologies of agricultural production. Most researchers in the agrarian economy ignore this fact or do not attach proper significance to it. For ten years, from 2006 to 2016, the share of marketable products produced by holdings in relation to all agricultural products increased from 26.5 to 53.5%. In 2006, holdings produced marketable products per employee that were 4.6 times more than independent agricultural organizations; in 2016, they were 10.1 times more.

For the analyzed period, the share of profit of agricultural holdings in the total profit earned by agricultural organizations increased from 25.1 to 55.7% [7]. Agroholdings became the main producers of commodity products and profits in agriculture and provided faster growth in labor productivity compared with other agricultural enterprises [1].

Table 2 Labor productivity index for Russia and the main sectors of the economy of the Russian Federation (according to Russian classifier of economic activities) in 2003–2014

	2003–2007	2008	2009	2010	2011	2012	2013	2014	2003–2014
In general, in the economy	107.4	104.8	95.9	103.2	103.8	103.3	102.2	100.7	103.8
Agriculture	103.9	110.0	104.6	88.3	115.1	100.2	106.2	103.3	103.8
Manufacturing	106.2	102.6	95.9	105.2	105.6	104.8	100.8	102.8	103.9
Mining	105.8	100.9	108.5	104.3	102.7	100.3	105.6	96.1	103.9
Production and distribution of electric energy, gas, and water	101.5	102.1	96.3	103.0	99.8	100.2	99.1	100.2	100.6
Wholesale and retail trade	108.2	108.1	99.0	103.6	101.9	102.1	99.6	98.7	104.4
Building	109.2	109.1	94.4	99.6	105.2	101.4	98.2	98.4	104.4
Hotels and restaurants	105.8	109.2	86.7	101.7	102.3	101.9	100.6	99.8	102.4
Transport and communications	107.3	106.4	95.4	103.2	105.4	102.2	100.4	100.4	104.1
Real estate operations	107.7	107.5	97.5	104.0	99.6	100.8	108.0	98.6	104.4

Source Compiled by the authors based on data from [4]

From 2003 to 2007, when the role of agricultural holdings in the production of marketable products and profit was not yet decisive, the growth rate of labor productivity in agriculture was half that of the average for the economy (see Table 2); 3.9% versus 7.4%. From 2008 to 2014, when the role of holdings in agriculture was gradually becoming decisive, the average annual growth rate of labor productivity in the economy is 101.9%, in agriculture—103.65%, and in the extractive industries—102.9%.

The outstripping growth rates of labor productivity in agriculture are connected precisely with the increasing role of holdings in the production of marketable agricultural products, because the production of marketable products per person employed in holdings, as we have seen, is more than ten times higher than that in independent agricultural organizations.

There is no reason why the trend towards the further holding of agriculture should not continue, so it will ensure faster growth of labor productivity in agriculture compared to other industries in the coming years.

However, holdings, most likely, will not cover all agricultural organizations—some of them will be unattractive for holdings or will resist inclusion in holdings. In any case, the outcome of the struggle will be decided by competition. The creation of equal conditions for competition for all types of agricultural organizations is beneficial for the state since this will contribute to the quickest victory of the strongest. Therefore, the strongest farms that require less help from the budget will stay afloat.

On the other hand, competition itself between the forms of management will contribute to achieving better results and the outstripping growth of labor productivity in agriculture. The same will be promoted by farms of different types in the procurement and sharing of high-performance equipment, the creation of common facilities for storage, processing, and marketing of products.

Table 3 shows the importance of creating a favorable competitive environment for the development of both individual types of economic activity, and for the economy as a whole. The period from 2015 to 2017 is known as the War of Sanctions: economic sanctions against Russia and retaliatory sanctions from Russia against the restrictive actions of the United States and the European Union.

In international trade with economically developed countries, sanctions restrict the export of high-tech goods to Russia. Obviously, this hinders the modernization, that is, the technical re-equipment of many sectors of Russian industry due to restrictions on exports to Russia, which contribute to the solution of this problem. As a result, we can see that, for example, manufacturing out of three years shows growth of less than one percent. Information and communications activities show stagnation and an artificially induced decline. Mining shows low growth rates similar to the overall economy.

Agriculture, under the influence of reciprocal Russian sanctions, stopped importing low-quality agricultural products at dumping prices, which significantly improved internal competition between agricultural enterprises. As a result, in the analyzed period, the growth rate of Russian agriculture is 3–4 times higher than the average growth rate in the economy.

Table 3 The growth rate of labor productivity in the economy and its main sectors in 2015–2017

Indicators	2015	2016	2017
In general, in the economy	98.9	100.2	101.9
Agriculture, forestry, hunting, fishing, and fish farming	104.2	102.6	105.3
Including			
Agriculture, forestry, hunting	103.6	103.0	105.9
Fishery, fish farming	111.2	91.3	84.7
Mining	99.5	100.3	101.6
Manufacturing enterprises	100.7	102.4	100.7
Providing electric energy, gas and steam; air conditioning	100.4	101.1	100.1
Water supply; water disposal, organization of waste collection and disposal, pollution elimination	91.5	100.1	96.7
Building	100.8	102.3	97.6
Wholesale and retail trade; repair of vehicles and motorcycles	93.4	96.4	101.7
Transportation and storage	100.3	100.8	100.0
Activities of hotels and catering establishments	98	94.1	103.5
Information and communications activities	101.4	93.7	99.0
Real estate activities	99.4	99.6	100.4
Professional, scientific, and technical activities	94.2	94.7	108.4
Administrative activities and related additional services	109.5	103.9	98.6

Source Compiled by the authors based on data from [5]

Thus, the key question of the organization of markets of agricultural products (the solution of which partly depends on economic growth, the level and dynamics of labour productivity, and volumes of production) is the issue of market efficiency and preventing competition restrictions, as well as creating equal conditions to compete for foreign manufacturers in Russia and for Russian manufacturers in other countries.

5 Conclusion

Market efficiency means the inability for players to constantly make a profit or its share, not related to the efficiency of their economic activity, due to their monopoly position, restricting others from accessing the market.

The more efficient the market, the more it forces manufacturers to care about the efficient use of resources, lowering costs, improving the product, and creating new innovative products. The higher the level of production, the better the labor productivity.

Improving the organization of markets for products, resources, and money in the field of agricultural production in order to increase their efficiency is the most important condition for increasing the growth rate of labor productivity and the international competitiveness of the industry.

Caring for market efficiency is an alternative to increased budgetary investments in agriculture, which hinder competitiveness.

Not only the prevention of excessive concentration of production, but also the prevention of sharp differences in the income level of monopolists and organizations of related sectors of the economy is quite possible to implement in ways that do not reduce but increase motivation for innovation and increase labor productivity.

References

1. Bogoviz, A.V., Lobova, S.V., Ragulina, J.V., Chutcheva, Y.V., Bykovskaya, N.V.: Increase of labor productivity in the agrarian sector: a view from the standpoint of a modern man. Qual.—Access Success **19**(S2), 103–107 (2018)
2. Bogoviz, A.V., Vukovich, G.G., Stroiteleva, T.G.: Developing a systemic labor motivation in enterprises. World Appl. Sci. J. **25**(10), 1429–1431 (2013)
3. Federal State Statistics Service: Official statistics on science and innovation. Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/science (2017a)
4. Federal State Statistics Service: Official statistics on labor. Retrieved from www.gks.ru/free_doc/new_site/vvp/vvp-god/pr-tru.xlsx (2017b)
5. Federal State Statistics Service: Official statistics on labor productivity. Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/# (2017c)
6. Kurakova, N.G., Zinov, V.G., Tsvetkova, L.A., Eremenko, O.A., Komarova, A.V., Komarov, V.M., Sorokina, A.V., Pavlov, P.N., Katsyubinsky, V.A.: National Science and Technology Policy of "Rapid Response": Recommendations for Russia: Analytical Report. Delo, Moscow, Russia (2014)
7. Shagayda, N.I., Uzun, V.Y.: Drivers of Growth and Structural Changes in Russian Agriculture. Delo, Moscow, Russia (2019)

Firm as an Innovative Structure

Vassily D. Kuligin, Ivan D. Matskulyak, and Ekaterina N. Bykovskaya

Abstract The purpose of the study is the functioning of the company as an innovative structure of the modern economy. In its activities, the company is guided by innovations obtained through the use of modern research methods—the collection, processing, and grouping of facts, their analysis and synthesis, scientific abstraction and generalization, logical and historical unity. The authors focus on a universal pattern of the division of knowledge, as well as consider "just" as a general tendency of the labor division in theory and practice. The research confirms that the division of knowledge is created, matures, and spreads in the form of various information in the firm (organization, enterprise, and other structures). It is the innovative activity of current firms producing goods and providing services that supports and ensures the continuous economic growth of any society. The sharing of knowledge, its combination, and practical testing form innovative information are also discussed by the authors. The latter is the result of the internal activities of the company itself and its interaction with other organizations. The relationship of the company with the sphere of exchange (i.e., the market) is disclosed. Both structures become the engine of long-term economic growth, the authors argue. The company is considered as an external product of a functioning market. As a definite independent structure, it plays a special role in the implementation of production. The latter does not remain the same but changes in strict accordance with changes in the sphere of exchange (market), affecting, in turn, production.

Keywords Company · Innovation structure · Knowledge · Pattern of knowledge sharing · Information · Economic growth

V. D. Kuligin · I. D. Matskulyak (✉) · E. N. Bykovskaya
State University of Management, Moscow, Russia
e-mail: mid48@mail.ru

V. D. Kuligin
e-mail: vassily_kuligin@mail.ru

E. N. Bykovskaya
e-mail: byko33@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_38

1 Introduction

In modern conditions, the possibility of accelerated economic growth is usually associated with a change in the structure of production. The latter is being transformed under the influence of a constantly ongoing deepening of the division of labor, which, apparently, is of an objective natural-historical nature. The course of this process causes the problem of the division of knowledge, which, according to F. Hayek, is similar to the problem of the division of labor. It is also important [1]. The separation and emergence of new knowledge become a catalyst for the transition to a fundamentally different technological basis of production. At the same time, new organizational structures are emerging that shape the environment where innovation is possible [2].

2 Materials and Methods

The aim of the paper is to study the company as an innovative structure of the modern economy, which in its activities not only takes into account market innovations but also implements its own actions. In this regard, in the course of the work, the following tasks were solved: revealing the internal innovative potential of the company and the role of information in its manifestation, identifying the external influence of market innovations on the functioning of the company, and summarizing the manifestation of the synergy of innovative synthesis of the company and the market.

The object of the study is the main link in the economy, the company, in its broad description in the form of organizations, enterprises, associations, companies, corporations, etc. The subject is socio-economic relations between market entities of entrepreneurship regarding the activities of firms as innovative structures of the national economy.

The following methods were used in work: collection, processing, and grouping of facts, analysis and synthesis, scientific abstraction and generalization, the unity of the logical and historical, etc. These methods made it possible to focus theoretical and methodological efforts on key points of the problem under consideration.

3 Results and Discussion

The spread of innovation in the market environment creates the necessary conditions for increasing returns in both manufacturing and services. It sets in motion the principle of increasing returns, when with the expansion of production, at the same time reducing costs per unit of output. The larger the volume of production, the lower the cost per unit of production. In other words, decreasing costs correspond to increasing returns [6]. This circumstance increases the skills of workers, saves time, ensuring the growth of labor productivity or the ever-increasing return on production. Under these conditions, most likely, the following thought of A. Smith is realized. A necessary attribute that accompanies the development of the productive power of labor is, according to him, a significant share of the art, ability, and quick wit of the workers themselves [7]. In this context, information becomes an essential resource.

The facts confirm that knowledge formed the basis of practical activity and became a fundamental factor of modern economic growth. It is the innovative activity of current firms producing goods and providing services that ensures and supports continued economic growth. Meanwhile, innovation is, at best, a peripheral part of a firm's standard theories. At the same time, the company, thanks to innovations, can improve its own position, while supporting economic growth. This implies the identification of a stable internal relationship between the activities of the company and the sources of growth generated by it. Innovations resulting from the internal activities of the company itself and its interaction with other companies become the engine of long-term growth.

In a broad, philosophical sense, the nature of the firm is largely unclear. According to A. Smith, the tendency to exchange gave rise initially to the division of labor [7]. However, this may be objected to, since before anything is exchanged, it must be produced. In this case, production precedes exchange, which means that it can be assumed that "firms precede markets". There is still no definitive answer to such questions as "What is a firm" and "Why do markets exist". In the available literature, we can find different answers to the posed questions. It is thought, however, that the activities of the company are organically linked to the market. It can be characterized by such fundamental categories as the division of labor and exchange. The appearance of the latter is not the result of anyone's wisdom, foreseeing, and awareness of the well-being that will be generated by them. Human nature did not initially have in mind such a useful goal [7]. The listed categories appear as finite reality, not amenable to further analysis and reduction to something more fundamental [5].

Based on the content of these categories, L. Mises characterizes the behavior of an individual or group of individuals as follows: Each individual, he says, and therefore each group of individuals, seeks to exchange the worst state of affairs for the best, which they consider more satisfactory. In this sense, they pursue their own interests. The question of what is more and what is less desirable is decided by current individuals. This is the result of choosing from a variety of possible solutions. The choice is determined by the subjective ideas of individuals about the consequences that these various conditions may have on their own well-being [5]. It follows that the exchange, in which an organized group of individuals participates and to which the company belongs, always strives to exchange the worst state of affairs for the best. This is precisely what interests it. At the same time, the company always has a wide range of opportunities for realizing its interest. It chooses the best ways to achieve the goal.

The specificity of the exchange itself gives the following characteristics to its participants: the company is an external product of the current market, and this generation is represented by internally organized, isolated factors, which, functioning, is not directly supported by the existing market structure. Being a certain independent unit, the company assumes a special function in the implementation of production.

Production itself deals with a set of specific capital goods, each of which serves well-defined purposes. Various elements of capital are initially included in the subjective plan of the production process. In other words, manufacturing things implies the existence of a well-defined, natural-material capital structure represented by specific-use values. This approach is radically different from the mainstream tradition, which in its models considers capital as some kind of internally unstructured aggregate stock value "K".

At some point in time, the heterogeneous natural-material structure of certain types of production may seem to correspond to the structure of existing demand in terms of its volume and quality and, therefore, be supported by market forces. However, the ever-changing size of the market and the dynamics of needs lead to a violation of this apparent conformity. In this case, the highly specialized production structure is no longer supported by market demand. It closes within the "dead-end of specialization" [3].

The emerging imbalance, indicating the limitations of existing production methods, creates the necessary conditions for the emergence of the company. Capital heterogeneity and market uncertainty inherent in the market put restrictions on the adoption of entrepreneurial risk. The latter, embodied in capital goods in the form of materialized proportions, can only be changed with new investments. Many of the proposed and heterogeneous projects require a decrease in the specificity and complementarity of production factors within risky areas. At the same time, markets for intermediate goods created and used in such projects do not exist. At the same time, each starting project does not fit in; that is, it is external to the current market means of its implementation. This means that the creation of new specialized products related to more specific intermediate capital goods is not supported by markets [3].

An equally important fact is the following circumstance: Any ongoing investment process is extremely sensitive to unexpected, uncertain change. The uncertainty of such a factor as innovative choice can result in huge irrevocable costs. This gives an idea of the importance of social and legal conditions of doing business. At the same time, an entrepreneur operating in a company needs committed investors and other participants in a joint venture in order to implement the project and to continue in difficult times.

Therefore, the only way to implement these projects is the organization of "specific humanitarian integrity" around it; that is, the company [3]. In this context, this means that firms are the only rational channels for bringing innovation to society. A firm can be seen as a mechanism that can unlock the "dead end of specialization." Thanks to it, an opportunity opens up for the implementation of those projects that, for various reasons, have not been introduced into the market or have not been verified and supported at every step of the way. Such support implies the profitability of the project. The latter, as shown above, means the constant desire to replace less satisfactory conditions with more satisfactory ones. It is inherent in human nature itself [5].

A firm operating on the market, which is at the same time a non-market phenomenon, should probably be regarded as an agent of permanent change. Its unique function is to adapt the structure of production to the dynamics of market needs. The company, most likely, is a creative realization of an entrepreneurial ideal, the ultimate and final cause of itself: an organized project, driven by an imaginary wave of the future [3]. The idea expressed here is consistent with the understanding of the company by L. Mises. According to him, the innovators should not wait for an invitation or order from anyone. They can go forward of their free will and challenge traditional teachings [5].

A shift in emphasis on the dynamic unblocking of part of the organization allows us to consider the company as a structure that organically fits into modern growth theory. This interpretation differs significantly from the theories of the company, focusing on the legal parties, the supported hierarchy, or the explanation of the existence of the company by reference to specific economic costs [3].

Based on the fact that the cause of the emergence and subsequent preservation of the company is the innovative activity of entrepreneurs, they face very difficult tasks. Their job is to change the present and achieve their goals in the future [7]. The difficulty is that the potential entrepreneur is dealing with the uncertain circumstances of the future. The success or failure of its activities depends on the accuracy of anticipating uncertain events. The entrepreneur relies entirely on the ability to better understand the conditions that will develop in the market in the future than his competitors [4].

An entrepreneur makes a profit by combining factors of production that are adequate to changing circumstances. In specific conditions, he has to constantly look for new options for combining and harmonizing the resources consumed, while achieving their release or economy. In order to do this, he needs information and knowledge. Knowledge is an ideal product, a product of mental labor, which is produced by the entrepreneur himself. The information is in the differences. The search for these differences, their comparison and assessment, from the point of view of the possibility of improving the position of the company on the market, is a very difficult task for the entrepreneur. Ultimately, this work is associated with the discovery of hidden, previously unknown prospects and means of profit. First of all, this is probably the meaning of the innovative activity of the company.

Entrepreneur efforts must be supported by an appropriate environment. The decisive role is played by the ability not only to produce information but also the ability to consume it. There are the problems of perceiving the gained knowledge, being aware of its importance, and understanding the prospects for its use. Nowadays, the collection, processing, and storage of big data and, most importantly, the ability to use them to get answers to a variety of questions are very relevant. The acquisition of information and knowledge is followed by its materialization and objectification, and this is not a simple process, requiring a high level of education and qualification of employees. In this case, we are dealing with a limitation, not in the availability of knowledge, but with the possibilities of its consumption [8].

In the created information environment, increasing returns are generated by both perfect and imperfect market structures. One of the important insights of the information economy, notes J. Stiglitz in this connection, is that information about a product and competition will usually be imperfect. However, even with perfect competition, it is possible for companies to use market power, and indeed, thanks to imperfect and expensive information, actions are being taken that strengthen their market power [9].

4 Conclusion

A company operating on the market, which is also a non-market phenomenon, should be considered an agent that continuously responds to permanent changes in incoming information. Its main function is to adapt the structure of production to the dynamics of market needs. Maintaining compliance between them is entirely based on the creative activities of entrepreneurs who, being in market conditions, have freedom of choice. Its end result is the exchange of the existing position by the firm for the best. The environment contributes to this.

Most modern economies have an information sector in which knowledge production is concentrated. Information is created in companies in collaboration with universities. It can be assumed that this is why universities, which become the analogue of monopolistic corporations in the field of science and education, claim the role of the main social institution. The production and consumption of information significantly expand the field of information services. The latter receives and makes information products available to the user. Their use in the field of innovative and high-tech business is becoming a key factor in creating added value. Services provided to businesses make a decisive contribution to improving the position of firms in the market while increasing the value of goods and services they produce.

References

1. Hayek, F.: Individualism and Economic Order. Chelyabinsk, Russia (2011)
2. Huerta de Soto, H.: Austrian School of Economics: Market and Entrepreneurial Creativity. Sotsium, Chelyabinsk, Russia (2011)
3. Machaj, M.: The problem of production: a new theory of the firm (book review). Q. J. Austrian Econ. **21**(4), 427–435 (2018)
4. Reinert, E.S.: How Rich Countries Became Rich, and Why Poor Countries Remain Poor. Moscow, Russia (2015)
5. Smith, A.: Research on the Nature and Causes of the Wealth of Peoples. Exmo, Moscow, Russia (2007)
6. Spiridonov, E.S., Klykov, M.S., Rukin, M.D., Grigoryev, N.P., Balalaeva, T.I., Smurov, A.V.: Information Economics. LIBROCOM, Moscow, Russia (2010)

7. Stiglitz, J.E.: The revolution of information economics: the past and the future. NBER Working Paper, 23780, 1–28 (2017)
8. von Mises, L.: Human Activities: A Treatise on Economic Theory. Chelyabinsk, Russia (2008)
9. von Mises, L.: Theory and History: Interpretation of Socio-Economic Evolution. Chelyabinsk, Russia (2013)

The Analysis of the Structure and Assessment of the Sources of Financing of Technological Innovations

Ekaterina N. Bykovskaya, Yuliya N. Kafiyatullina, and Gocha P. Kharchilava

Abstract Currently, innovation activity in Russia remains low. At the present stage of development in our country, an adequate and effective holistic system that ensures the smooth functioning of the innovation process has been created. After the collapse of the Soviet Union, apologists for a market economy, unfortunately, were unable to create the necessary institutional conditions that would allow the formation of a holistic model of the innovation process at the micro and macro levels. The evidence of this is the sharp reduction in the number of scientific organizations and experimental design bureaus, the lack of demand for trained highly qualified personnel (engineering, technical), which, in turn, has a serious impact on Russia's innovative and technological lag behind developed countries. The ability and potential of creating and implementing technological innovations depend on the efficiency of the functioning of financing mechanisms and the state of investment sources that create a favorable economic environment for innovation activity. The paper analyzes and evaluates the structure of financing sources of technological innovations. A comparative analysis of research and development funding in developed countries and Russia is conducted. Based on the analysis, the authors identified shortcomings and assessed the effectiveness of existing mechanisms and sources of financing innovation.

Keywords Research and development · Innovative activity · Financing · Technological innovations · Problems

E. N. Bykovskaya (✉) · Y. N. Kafiyatullina · G. P. Kharchilava
State University of Management, Moscow, Russia
e-mail: byko33@yandex.ru

Y. N. Kafiyatullina
e-mail: yn_kafiyatullina@guu.ru

G. P. Kharchilava
e-mail: ts-5@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_39

1 Introduction

The object of this study is the sources of financing for innovations created in Russia. Innovation is the engine of the country's economic development. In order to ensure high rates of innovation at the macro and micro levels, it is necessary to create a number of institutional conditions. The state, and in particular ministries and departments, creates mechanisms that can stimulate the redistribution of capital in the sectors of the economy where the results obtained subsequently form the basis of a new technological structure. A significant impact on the dynamics of innovation is provided by the effectiveness of the functioning mechanisms for financing such activities.

Historically, in Russia, research and development, which form the basis of breakthrough technological innovations, are funded by the state. At the same time, the activity of the state and its interference in the economy is fraught with abuse of power (corruption, upholding of interests of special groups, etc.), as well as the irrational and inefficient use of economic resources. Often, a state person (official), not being the ultimate beneficiary, is not motivated to create innovation. On the contrary, venture and private funds, which are guided by profit and risk, have a high interest in financing innovation [4].

For example, investments in innovations in the sphere of the military-industrial complex (hereinafter referred to as the MIC) are carried out by the state, which is expedient and reasonable since such developments protect the country's national interests. It is worth noting that the main discoveries made in the field of the defense industry have found applications in other sectors of the national economy. The free circulation of intellectual property or the results of innovative activities increase the diffusion rate of innovations. The diffusion of breakthrough innovations based on fundamentally new discoveries entails structural changes in the country's economy.

Organizations can initiate partial reconstruction on a new technological basis on their own. The key point is the desire of management to introduce innovations. The motive for entrepreneurs who are among the first to introduce innovations is to generate excess profits.

2 Materials and Methods

In the theoretical part of the study, the classifications of innovative activity developed by domestic scholars and the types and mechanisms of financing used for the implementation of innovative projects are used. The analysis and evaluation of the effectiveness of the functioning of such mechanisms are carried out on the basis of statistical data presented on the Rosstat website, in statistical yearbooks, in collections published by the Higher School of Economics (HSE), and in the Global Innovation Index report for various periods. All collections are in the public domain and contain an exhaustive list of information for a detailed analysis of the R&D

state in Russia in various sections. The statistical study was carried out using the methodology for calculating the absolute and relative statistical values.

Advantages and disadvantages, the effectiveness assessment of the way financing mechanisms are functioning Russia are revealed by the method of comparative analysis of domestic experience with the world.

By analyzing the evolution and specifics of the development of the innovation process, it is possible to carry out a conditional classification (of objects, links, industries, stages): (1) fundamental scientific research, (2) applied research, (3) innovative business, including commercialization of developments [1].

All sources of financing can be divided into state, private, and mixed (public–private).

There are various forms and methods of state participation in financing innovative activities (projects), namely: budget financing of scientific institutions, state orders for research and grants, the creation of specialized funds and institutions, favourable tax conditions, favourable investment loans, favourable loans for scientific and technical projects and funding for basic R&D.

In economically developed western countries, special attention is paid to the formation and development of financial infrastructure, where venture financing plays a key role. It provides the establishment and dynamic development of high-tech companies. In modern conditions, venture financing has transformed into one of the most popular and effective tools for financial support of technological innovations and the development of the innovation sphere, which, in turn, contributes to the rapid development of advanced scientific and technological developments to create competitive high-tech products. Venture financing is the essence of venture entrepreneurship. It represents a search and is, therefore, the riskiest link in innovation. The organizational structure of venture entrepreneurship is the venture capital fund. Having significant potential, venture funds can quickly mobilize the necessary resources in order to finance technological innovations with the lowest transaction costs. The main task of venture capital funds is to invest accumulated funds in promising and profitable innovative projects. At the present stage, the innovative development of any country is impossible without an efficiently-functioning national innovation system. The basis of this system is venture entrepreneurship [6].

Innovative economic development requires the attraction of large-scale financial resources. Investments in innovations involve a high degree of uncertainty and, accordingly, high risk. However, at the same time, they suggest the potential for a high rate of return. Cooperation between public and private entities can take the form of public–private partnerships. By actively participating in financing large joint innovative projects, the state, with its resource potential, demonstrates its own risk and willingness to share the risk with a private investor. This will change the risk-return ratio for private investors. In addition, favorable conditions are created for private businesses to extract higher incomes than traditional businesses. In these conditions, private investors provide investment activity and high capitalization in the dynamically developing, promising high-tech sectors of the innovative economy. In turn, the state overcomes, through private investment resources, the budget deficit from innovative resources, increases the efficiency of innovative projects by attracting various resources (e.g., human, technological, managerial, organizational), optimizes risks, and reduces government spending. State investments in venture funds contribute to the accumulation of the necessary financial capital for the development of venture capital business and investment in innovative projects. The development of private state funds at the federal, regional, and sectoral levels, aimed at financing innovative projects of high-tech sectors of the innovative economy, can be carried out on the basis of capitalization on an equal footing at the expense of various private funds and budgets of various levels.

Regardless of the type of funding source, it is worth noting that the speed of generating ideas is so high that the investor does not have time to pay back the invested funds. Financing an innovative project can be carried out at the expense of various sources. Theory and practice have the acute question of determining the configuration of funding sources depending on the specifics of the innovation project.

3 Results

During the period from 2000 to 2016, financing of technological innovations at the expense of own funds decreased by 20% in the structure of funding sources, and funding from the federal budget, the budgets of the constituent entities of the Russian Federation, and local budgets decreased by 4.5 times, which is not typical for countries with a developed market economy.

About 53% of the total cost of technological innovation is spent on the purchase of machinery and equipment; according to the data presented in the HSE collection, in the financing structure, 62% of own funds are invested in the technological re-equipment of fixed assets. It should be noted that machinery and equipment are mainly purchased abroad. Since own funds are one of the cheapest sources of financing and machines and equipment are mainly of foreign production, there is an outflow of capital and, accordingly, the investment goes to the economies of other countries.

In addition, this scheme is associated with additional risks (political, economic, and financial) and possible costs, since real activities are carried out in a situation of structural uncertainty.

About 24% of the total cost structure for technological innovation is directed to research and development [3].

In the strategy of the socio-economic development of the state, it is advisable to invest budget money in R&D, obtain results in the future, and ensure a continuous cycle of research and development.

The subjects of innovation when choosing the best available and possible sources of financing can be guided by the following criteria: the amount of financing using this financing option; cost of source; loan term; additional conditions and restrictions; the difficulty of gaining access to this source of funding; and the presence of a market for the provision of services for the selected type of borrowing.

The lowest indicator in the structure of costs for technological innovation is the acquisition of rights to patents and licenses and software, 0.9 and 1.1%, respectively.

These indicators show the presence of institutional problems, namely the quality of regulatory documents that protect the ownership of these products. Without a radical solution to these problems, no country's economy will be able to overcome or make a technological breakthrough that provides a worthy place among the technologically developed countries of the world [2].

In countries with developed market economies that manufacture products and services of a dominant technological structure, the structure of costs for technological innovations is as follows: research and development by own forces (Austria—67%, Denmark—62.4%, Finland—72.3%), research and development carried out by third parties (Austria—8%, Denmark—22%, Finland—14%), the acquisition of machinery, equipment, and software (Austria—18%, Great Britain—28%, Germany—23.5%), and virtually no acquisition of new technology (the figure varies at 2.5%). In 2015, 23.6% of organizations engaged in technological innovations cited a lack of equity as a factor that impedes technological innovation, the high cost of innovation—17.1%, and 12.3%—a lack of financial support from the state [3].

Borrowed capital and organizations' own funds can act as other sources of financing. It is advisable to use these types of sources to service current operating activities. Bank loans are attractive for the company by the comprehensibility of the applicable rules, clear criteria for obtaining borrowed funds and a wide variety of loan products, flexibility in determining the terms, rates, and amounts of financing. Commercial loans are used in the activities of any organization. The company both receives and provides them in the form of advances and deferrals of the fulfillment of obligations. An ideal, though rarely implemented in practice, option is to obtain commercial loans from suppliers and buyers in large volumes and for longer periods than their advance.

In Russia, the contradiction between the real sector of the economy and the financial sector continues to grow. S. Yu. Glazyev, the academician of RAS, in his book "Charge into the Future of Russia in New Technological and Economic Structures" notes "The Central Bank's policy of artificially raising interest rates forces enterprises to lend abroad, withdrawing the same income there in order to repay and secure their loans. The total losses of the country's financial system due to the actions of the Bank of Russia are estimated at more than $1 trillion for the accumulated export of capital. Taking into account indirect losses caused by underfunding of domestic investments, they're twice as much [5].

4 Discussion

In Russia, at the present stage of development, it is clear that the created mechanisms do not provide sufficient financial means to market agents. As for investments in innovative activity in Russia, such sources of financing as venture funds and funds supporting scientific and innovative activities do not participate in the creation of technological innovations, while such sources of financing should function efficiently and are some kind of indicator of the development degree of a market economy.

5 Conclusion

The investment process can be implemented through independent corporate venture funds, corporate venture funds as part of a corporation (funds can exist as a separate legal entity), or it will be a state fund. The question always concerns how communication will be organized. Often the success of the project itself depends on successful communication.

Acknowledgements The authors would like to thank the colleagues of the State University of Management for their help and scientific advice in the process of writing this paper.

References

1. Barancheev, V.P., Maslennikov, N.P., Mishin, V.M.: Innovation Management. Textbook for Bachelors, 2nd edn. Urait, Moscow, Russia (2015)
2. Bykovskaya, E.N., Kafiyatullina, Y.N., Kharchilava, G.P.: Current trends in the digitalization of the innovation process. Management **1**, 38–44 (2018)
3. Efremov, V., Vladimirova, I.: Business uncertainty as a factor of a corporate strategy. In: Proceedings from AEBMR: Advances in Economics, Business and Management Research; ICPEL 2017: 2nd International Conference on Politics, Economics and Law. Beijing, China: Atlantis Press (2017)
4. Glazyev, S.Y.: The great digital revolution: challenges and development prospects for 21st century Russia (2017). Retrieved from https://www.glazev.ru/articles/6-jekonomika/54923-velikaja-tsifrovaja-revoljutsija-vyzovy-i-perspektivy-dlja-jekonomiki-i
5. Glazyev, S.Y.: Charge Into the Future of Russia in New Technological and Economic Structures. Knizhnyj mir, Moscow, Russia (2018)
6. Stiglitz, J.E.: The revolution of information economics: the past and the future. NBER Working Paper, 23780, 11 (2017)

Prospects for the Development of High-Tech Sectors of the Economy of the Russian Federation

Tatyana A. Samsonova and Oxana A. Fesyanova

Abstract The paper focuses on the analysis of the prospects of high-tech sectors of the Russian economy, the relationship of their development with the global financial crisis. The authors highlight critical features of such industries in Russia, outline possible scenarios, and provide recommendations and for the development of industries.

Keywords High-tech industries · High-tech companies · Innovation · Scientific research · Technological structure

1 Introduction

The object of this study is to examine the high-tech sectors of the economy of the Russian Federation and the possible prospects for their further development in the modern Russian and world economy. First of all, it should be noted that the high-tech industries of our country are characterized by a number of features that distinguish them from other industries, namely:

1. There are different ways of classifying what exactly amounts to "high-tech industries", "high-tech companies", and "innovative companies" in Russia and the world. There is no unified international classifier. Different consulting firms, public organizations, institutes, and research centers, engaged in researching these issues, such as the Boston Consulting Group with their annual rating, the Global Innovation Index of Cornell University (INSEAD), the World Intellectual Property Organization (WIPO), Massachusetts University of Technology's MIT Technology Review, and Drucker Institute's company ranking, take the basis of their calculations, which are the basis for compiling ratings, and various initial

T. A. Samsonova · O. A. Fesyanova (✉)
Lomonosov Moscow State University, Moscow, Russia
e-mail: fesyanova@cosmos.msu.ru

T. A. Samsonova
e-mail: samsonova@cosmos.msu.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_40

data and differently rank the received results. As a result, comparing the results obtained and trying to reduce them to something uniform is a difficult task for a researcher. In addition, even within the framework of our state, there are discrepancies regarding the same issues. Thus, the legislation defines as high-tech industries (that is, high-tech companies are those that belong to the industries declared in this list) a closed list of several items. Meanwhile, the domestic ranking of high-tech companies like TechUspeh, which has been publishing results since 2012, uses completely different methods for identifying and classifying companies as high-tech and innovative.
2. The practice has historically developed in such a way that in our country, high-tech industries have always been, to one degree or another, under the auspices of the state, both in the Soviet period of history and in the modern Russian period. This left a peculiar imprint on the management system, financing methods, and other important aspects. At the moment, industries are supervised through a special form of management—a state corporation—and it cannot be said that this form is perfect and that there is no tendency to search for and develop a more adaptive, modern, and relevant system for managing high-tech industries in Russia.
3. High-tech industries and companies do not exist in a vacuum; they are organically woven into the general structure of the state's economy, into the world market. As a result, they are also subject to structural phenomena in the economy, such as crises, stagnation, obsolescence, and updating of the technological base.

2 Materials and Methods

In this paper, the authors, through a systematic analysis, examined several open statistical sources of data related to high-tech industries, innovations, and R&D, namely: the Global Innovation Index of Cornell University (INSEAD) and the World Intellectual Property Organization (WIPO), a study by employees of the National Research University Higher School of Economics of the costs of R&D in the countries of the world, and open statistics on exports of high-tech products by country. The objectives of this study were to analyze these sources and identify general trends that had developed in the high-tech sectors of the economy over the past few years, to identify the place and role of Russia in this system, and to develop recommendations for domestic high-tech industries.

3 Results

In recent years, in scientific and practical research, as well as in the philistine understanding, there is an opinion that the flagships of the high-tech economy for more than a decade are economically developed countries such as the United States, Japan, and South Korea, and the rest of the countries can only catch up with these recognized leaders or even drag at the end of any ratings and indicators. However, the analysis of annual statistics (such as R&D costs), the number of researchers and scientific workers, the export of high-tech products, as well as the data of various international ratings of high-tech and innovative companies, does not give a clear picture.

Thus, according to the annually published rating [3], the Global Innovation Index of Cornell University (Cornell University, INSEAD) and the World Intellectual Property Organization (WIPO), the results of which are compared for 2016–2018 (Table 1), Russia in 2018 took 46th line of the rating from 126 countries represented in it.

The leaders are not the expected USA, Japan, and Korea, but instead, they are Switzerland, Sweden, Singapore, Great Britain, and the Netherlands. At the same time, such countries as China, Hong Kong, Israel, and Canada are confidently in the top 20, while more recent leaders (as of the beginning of the 2000s) Japan and Korea occupy 12th and 13th places, and the United States, even in the top ten (6th place), show a downward trend.

If we analyze the data on R&D expenditures, as well as on employment in this field of activity, then, according to the data provided by researchers at the Higher School of Economics National Research University (HSE) in Fig. 1 [5], we will see that, as of 2016, Russia closed the top ten countries with the highest R&D costs, which in itself is a good indicator. At the same time, the USA and Japan still hold the leading positions in terms of costs. However, China ranks second in the outlined trend towards massive growth in all aspects related to high-tech industries, combined with a high rate of busy researchers, second only to India and Brazil, which also in recent years have joined the race of innovations.

It is clearly seen that the internal costs of research and development often almost do not correlate with the number of researchers relatively employed in general and the cost of one researcher (in relative and absolute value to GDP per 1 researcher) not only in other countries, but also in Russia. On the one hand, this is a systemic problem, which may, in the future, with insufficient funding, result in an outflow of busy researchers from this industry. However, this picture, on the other hand, inspires hope that in the future, a qualitative breakthrough in the field of R&D is possible due to the large number of personnel with the continued financing of the state.

At the same time, we should not forget about such an important aspect of research and development results as the commercialization of the final product of these studies. If we analyze the ranking of the World Data Atlas [6], compiled on the basis of open sources and reports, by the absolute (in US dollars) indicator of export of high-tech goods, we will see the following picture for the last 5 years (Fig. 2):

With all the costs of R&D and the employment of researchers, Russia ranks 13th in the ranking and is significantly inferior even to such developing countries as Brazil, Mexico, and India. Over the past two years, our country has basically reduced exports, which raises concerns about the need for our high-tech world market products. At the same time, there is a drop in such previously recognized leaders of the market of

Table 1 Global Innovation Index ranking data for 2016–2018

Place	State	2018	2017	2016
1	Switzerland	68.40	67.69	66.28
2	Netherlands	63.30	63.36	58.29
3	Sweden	63.10	63.82	63.57
4	United Kingdom	60.10	60.89	61.93
5	Singapore	59.80	58.69	59.16
6	United States of America	59.80	61.40	61.40
7	Finland	59.60	58.49	59.90
8	Denmark	58.40	58.70	58.45
9	Germany	58.00	58.39	57.94
10	Ireland	57.20	58.13	59.03
11	Israel	56.80	53.88	52.28
12	Korea, Republic of	56.60	57.70	57.15
13	Japan	55.00	54.72	54.52
14	Hong Kong (China)	54.60	53.88	55.69
15	Luxembourg	54.50	56.40	57.11
16	France	54.40	54.18	54.04
17	China	53.10	52.54	50.57
18	Canada	53.00	53.65	54.71
19	Norway	52.60	53.14	52.01
20	Australia	52.00	51.83	53.07
21	Austria	51.30	53.10	52.65
22	New Zealand	51.30	52.87	54.23
23	Iceland	51.20	55.76	55.99
24	Estonia	50.50	50.93	51.73
25	Belgium	50.50	49.85	51.97
…				
46	Russian Federation	37.90	38.76	38.50

Source Annual reports of the Global Innovation Index for 2016–2018, published in the public domain in electronic form Global Innovation Index [3]

innovations and high technologies as the USA, Japan, and South Korea, and intensive growth in exports of China, Mexico, Brazil, and Eastern countries (such as Saudi Arabia, Israel) that just a few years ago did not claim to be at the forefront of high-tech industries, either in terms of costs or exports.

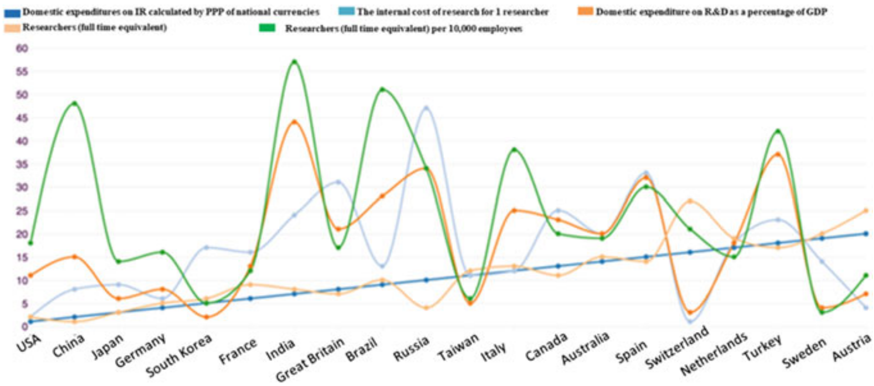

Fig. 1 Positions of countries leading in terms of domestic expenditures on research and development, according to the main indicators of science

	2017	2016	2015	2014	2013
1. China	504 380 837 924	496 007 481 292	549 799 008 829	558 599 126 108	560 058 333 865
2. Germany	167 746 057 022	189 646 012 435	185 556 246 410	199 718 151 684	193 799 440 986
3. USA	110 120 235 610	153 508 971 211	154 345 554 351	155 640 595 588	148 530 552 453
4. France	98 688 797 219	103 839 761 845	104 339 993 891	114 697 237 252	113 250 612 485
5. Japan	83 661 306 984	92 883 135 839	91 513 823 175	100 954 836 424	105 075 614 374
6. South Korea	72 699 710 197	118 364 816 867	126 526 384 316	133 447 400 828	130 460 427 536
7. UK	68 625 231 685	68 279 841 407	69 417 266 219	70 652 924 421	69 223 896 551
8. Mexico	50 434 980 272	46 809 600 476	45 780 911 356	49 402 709 617	45 418 666 690
9. Italy	27 787 004 391	27 905 531 647	26 927 145 887	30 744 972 831	29 711 962 935
10. Canada	24 220 179 630	23 974 176 827	26 318 082 109	26 552 175 610	29 025 961 547
11. India	14 455 947 950	13 335 887 306	13 750 546 786	17 315 676 298	16 693 424 357
12. Brazil	9 924 754 587	9 775 328 335	8 848 309 553	8 228 775 104	8 391 851 904
13. Russia	9 174 217 407	6 639 582 547	9 677 335 778	9 842 669 327	8 655 776 675
14. Australia	4 322 994 334	4 572 080 828	4 237 456 601	4 691 411 621	4 565 211 317
15. Indonesia	3 956 863 169	3 947 114 863	4 409 587 991	4 980 582 046	4 818 332 512
16. Turkey	3 052 401 326	2 182 767 291	2 323 079 468	2 346 682 136	2 176 908 249
17. South Africa	1 817 259 054	1 906 053 525	2 361 454 517	2 520 225 514	2 215 197 849
18. Argentina	1 447 746 846	1 300 925 701	1 442 450 760	1 473 214 194	1 745 160 318
Saudi Arabia	–	1 075 441 329	276 022 477	254 366 095	288 641 958

Fig. 2 Export of high-tech goods (in US dollars) for 2013–2017

4 Discussion

The economic crisis of 2008 and the ensuing long recession could not but affect the development of high-tech industries globally and in Russia, in particular. However, from the historical point of view, over the short period of its existence (according to various estimates, approximately from the 1930s), high-tech industries, along with the other sectors that shape the economy, have survived more than one local or global economic crisis, starting with the banking crisis of the 1930s in the United States and ending with the global crisis of the late 1990s. The last crisis was in 2008. However, in our opinion, it is impossible to consider the emerging trends in the decline of activity in individual countries (USA, Japan, and South Korea), which, for a long time, were recognized as locomotives of the world's high-tech industry as a consequence of only this latest economic crisis. Glazyev [1] rightly noted in his works that crises are not exclusively related to the financial sector of the economy and that it is not correct to consider such global crises as the one in 2008 as just a consequence of financial fraud in the security markets and in the banking sector. Having developed and deepened the theory of Kondratiev's cycles [4], S. Yu. Glazyev in his works [2] comes to the conclusion that humanity has historically gone through five stages—technological structures—each of which was marked, firstly, by the invention of a number of breakthrough technologies, which qualitatively changed not only the entire economic, industrial structure but also the everyday life of every person. Secondly, the invention of such technologies and their subsequent introduction marked a change in technological mode and often coincided with the most significant crises of the world economy. Based on this, Glazyev concludes that it is precisely the changes in technological patterns, and not exclusively financial or other economic causes and events, that primarily lead to worldwide economic crises. In addition, each new technological stage lasts less time than the previous one. That is, if the first stage lasted from its beginning to the end for several centuries, then the last, fifth, took only a couple of decades, and at the moment, the world community is on the verge of a new, sixth, technological order. It is with this transitional period that not only the apparent slowdown in technological and innovative spheres is connected, but also the global financial crisis and the stagnation that followed.

5 Conclusion

According to our study, we can conclude that the tendency to change the leaders of high-tech industries among countries revealed to us during the analysis and the observed tendency to decrease in the growth rate of both export of products of this kind and the growth of R&D costs, inconsistency of researchers employed in these industries in some countries with the growth rate of these same high-tech industries are explained not by the global economic crisis, which is a consequence in the form of stagnation still affect the global and national economy and not by the fact that there was a "glass ceiling" in the development of technology and the search for innovation but, above all, by the fact that such a situation is typical for the change of technological way. In the near future, together with a change in the technological mode, not only the advent of new leading countries in this field is possible, but also the formation of new, previously non-existent sectors of the economy and high-tech, innovative sectors can be noted. They will change the face of the world economy and the life of each person in the near future.

As a result, the following recommendations can be made for our country in the situation of the current transition:

1. It is necessary to continue financing and supporting R&D, ideas, and breakthrough inventions since we have the undeniable advantage of a large number of researchers and workers employed in this area of the economy. That is, the chance of breakthrough domestic technologies with such human capital is high and can be used properly;
2. There is a need for providing the opportunity for the exchange of experiences between representatives and researchers in this industry, as well as actively supporting participation in various international projects, forums, developments, and ourselves to create and support projects and developments of this level;
3. It is necessary to exchange not only experiences but the technologies and best practices themselves, first of all by buying technologies from other countries and introducing them into our own production, finalizing and adapting them if necessary. Such an approach will help to reduce Russia's lag in the technological race that is becoming faster every year.

References

1. Glazyev, S.Yu.: Theory of Long-Term Technical and Economic Development. VlaDar, Moscow, Russia (1993)
2. Glazyev, S.Yu.: The great digital revolution: challenges and prospects for the 21st century economy. Retrieved from https://glazev.ru/articles/6-jekonomika/54923-velikaja-tsifrovaja-revoljutsija-vyzovy-i-perspektivy-dlja-jekonomiki-i-veka (2017)
3. Global Innovation Index: Explore the interactive database of the GII 2018 Indicators. Retrieved from https://www.globalinnovationindex.org/analysis-indicator (n.d.)
4. Kondratiev, N.D.: Selected works. In: Abalkin, L.I., et al. (eds.) Economics, Moscow, Russia (1993)
5. Ratay, T.V.: Rating of the leading countries of the world in terms of science costs. Retrieved from https://issek.hse.ru/news/221864403.html (2018)
6. World Data Atlas. Export of high-tech goods: Retrieved from https://knoema.ru/atlas/topics/Исследования-и-разработки/Затраты-на-НИОКР/Экспорт-высокотехнологичных-товаров (n.d.)

Technical Modernization of the AIC: The Analysis of the Status and Prospects of Its Implementation at the Modern Stage

Andrey A. Polukhin, Mikhail R. Mikhaylov, and Alexey V. Tarakin

Abstract In recent decades, Russia has seen a downward trend in the number of agricultural machinery, which is associated both with dramatic changes in the country's economy, such as a decrease in cultivated land, a change in the organizational and legal forms of management, natural aging and retirement of equipment, and the global trend to increase the energy saturation of machines, leading to a reduction in their quantitative expression, as well as problems in production associated with the world financial crisis and the international political situation. The authors of the paper analyze the reasons that led to the current state of the agricultural machinery fleet, the results of the implementation of state programs focused on the development of agriculture and food markets in 2008–2013 and 2013–2020. Currently, there is a steady growth in the agricultural sector, which should also be supported by government support for updating the technical base. The solution to the above problems will help to maintain high rates of renewal of the fleet of agricultural machinery and ensure the successful implementation of the subprogram of technical modernization of the Russian agricultural sector.

Keywords Agricultural mechanization · Harvesting equipment · Technical modernization of agriculture · Food security of the Russian Federation · Provision of agricultural machinery

A. A. Polukhin (✉)
Federal Research Center of Agrarian Economy and Social Development of Rural Areas—All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: polukhinogac@yandex.ru

M. R. Mikhaylov · A. V. Tarakin
Orel State Agrarian University named after N.V. Parakhin, Orel, Russia
e-mail: mmichailov@mail.ru

A. V. Tarakin
e-mail: alexei.tarakin@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_41

1 Introduction

The dramatic changes in political life that took place in the 90s affected all spheres of society and led to dramatic changes, including in the economy and agriculture. The transition to market economic conditions has created the urgent task of increasing the use of agricultural machinery. The aging of the existing machine and tractor fleet and the increase in the energy saturation of modern machines and units have led to a fairly rapid reduction in the composition of the ICC with a simultaneous increase in the power range. This trend is typical not only for the conditions of the Russian Federation but also for other economically developed countries. However, it has its own specifics in our country. One of its features was the transition from a planned economic system, in which the main criterion for writing off the equipment was the established service life, to the operation of the limit state, which, depending on the forms of management and operating conditions, can occur both before and after the expiration of the planned period [7].

In 1985, according to the FAO (Food and Agriculture Organization of the United Nations), there were 2829 thousand tractors, and that number grew over the year by an average of 51 thousand, which allowed for quick updates and reflected the situation in both the Soviet Union and developed countries. For example, according to the Rhine Agricultural Society (Das Rheinische Landwirtschafts-Verbande (RLV)), the largest number of tractors in Germany was noted in 1985 and amounted to more than 1.5 million. In 2004, this figure decreased to 868 thousand, and in 2005, to about 833.2 thousand. Then, by the beginning of the 2000s, agricultural engineering in the Russian Federation turned out to be on the verge of collapse [8] (Table 1).

To overcome this situation, in 2007, by the Government of the Russian Federation's Resolution No. 446, the State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets for 2008–2012 was adopted. In 2012, the State Program for the Development of Agriculture and Regulation of Markets of Agricultural Products, Raw Materials, and Foodstuffs for 2013–2020 was amended by the Decree of the Government of the Russian Federation

Table 1 The number of tractors per 1000 ha in 1985

Country	Arable land (thousand hectares)	The number of tractors in agriculture (thousand units)	Arable land per tractor (ha/pcs)
USSR	227,156	2829	80.3
USA	187,765	4670	40.2
Canada	45,900	714	64.3
Australia	47,150	322	146.4
Argentina	29,000	204	142.2
Germany	11,957	1642	7.3
France	17,923	1491	12.0

No. 98 on February 8, 2019, changing the terms and stages of the program—extending the validity of the programs until 2025 in two stages (2013–2017 and 2018–2015) and the distribution of financial support for the state program [4].

The assessment of the results of the state program's implementation in 2008–2012 showed that only two constituent entities of the Russian Federation completed the tasks for the acquisition of equipment. The tasks for the implementation of the state program were completed for tractors in 13 constituent entities of the Russian Federation, for grain harvesting combines in 12, and for forage harvesters in 11 regions. The financial obligations of the federal budget to the subjects of the Russian Federation were fulfilled. The results of the implementation of the technical modernization subprogram of the agro-industrial complex of the State Program for the Development of Agriculture and the regulation of agricultural products, raw materials, and food markets for 2008–2012 show that, in order to improve the performance of the currently-implemented state program, it is necessary to analyze the progress of its implementation and develop recommendations for its successful implementation.

2 Materials and Methods

In order to evaluate and develop recommendations for improving the implementation of the subprogram of technical modernization of the agro-industrial complex, a comprehensive analysis is necessary for the current state and existing problems associated with updating production capacities used in the process of agricultural production. The information base of the study was departmental statistical data of the Unified Interdepartmental Information and Statistical System [2], final and operational reports of the Ministry of Agriculture of the Russian Federation, and independent and national reports on the progress and results of the implementation of the State Program for the Development of Agriculture and regulation of agricultural markets, raw materials, and food.

The objective of the study is to identify negative trends, to evaluate the effectiveness of the implementation of the technical modernization of the agro-industrial complex program, to determine the directions for its effective implementation, and to develop proposals for improving state regulation of the agricultural equipment market of the Russian Federation.

The key issue considered in the study is the possibility of ensuring high rates of technical modernization of the agricultural sector in all constituent entities of the Russian Federation.

3 Results

3.1 The Analysis of the State of the Agricultural Machinery Fleet

Since 1990, there has been a steady decrease in the ownership of agriculture machines in agricultural production enterprises of all forms. This trend has affected all areas of agriculture. Thus, the number of tractors decreased from 1365.6 thousand pieces in 1990 to 211.9 thousand pieces in 2018 (by availability at the end of the year), combine harvesters—from 407.8 thousand pieces to 72.3 thousand units, forage harvesters—from 120.9 thousand to 17.6 thousand (as of the end of the year in 1990 and 2018, respectively). The dynamics of changes in the quantitative composition of the tractor fleet of the Russian Federation are presented in Fig. 1, grain and forage harvesters in Fig. 2.

The decrease in the number of tractors and combines, as well as equipment for meat and dairy cattle breeding, was associated with the collapse of the existing system of the economy and the transition to new forms of management, which led to a reduction in cultivated areas. Thus, the area occupied by sown areas of grain and leguminous crops decreased from 63,068 thousand hectares in 1990 to 42,072 thousand hectares in 2003. After that, the growth, which amounted to 47,705 thousand hectares in 2017, began. The area occupied by sugar beets decreased from 1460 thousand hectares in 1990 to 1198 thousand hectares in 2017, potatoes from 3124 thousand hectares to 1350 thousand hectares, and vegetables from 618 thousand hectares to 535 thousand hectares in 1990 and 2017 years, respectively. An increase in sown area is observed only for sunflower, which increased from 2739 thousand hectares in 1990 to 7994 thousand hectares in 2017. The total sown area of agricultural crops in farms of all forms of ownership in the Russian Federation decreased from 117,705 thousand hectares in 1990 to 79,643 thousand hectares in 2018, and the load of arable land per tractor increased from 95 to 337 ha, and by one grain combine harvester—from 152 to 424 ha, respectively (Fig. 3).

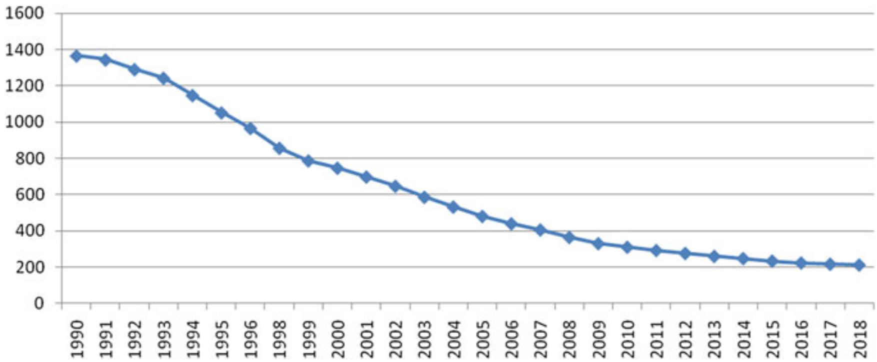

Fig. 1 The dynamics of the availability of tractors in farms of all categories in the Russian Federation, thousand units. *Source* Compiled by the authors according to the Rosstat data [2]

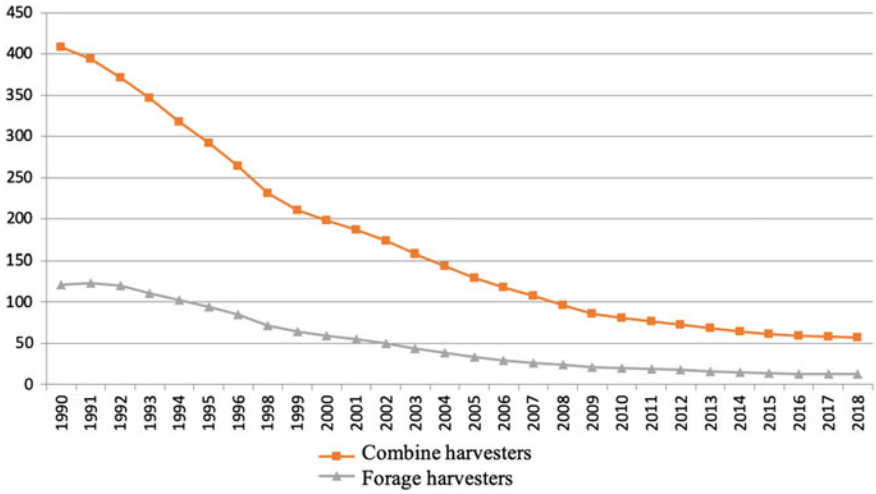

Fig. 2 The dynamics of the availability of grain and forage harvesters in farms of all categories in the territory of the Russian Federation, thousand units. *Source* Compiled by the authors according to the Rosstat data [2]

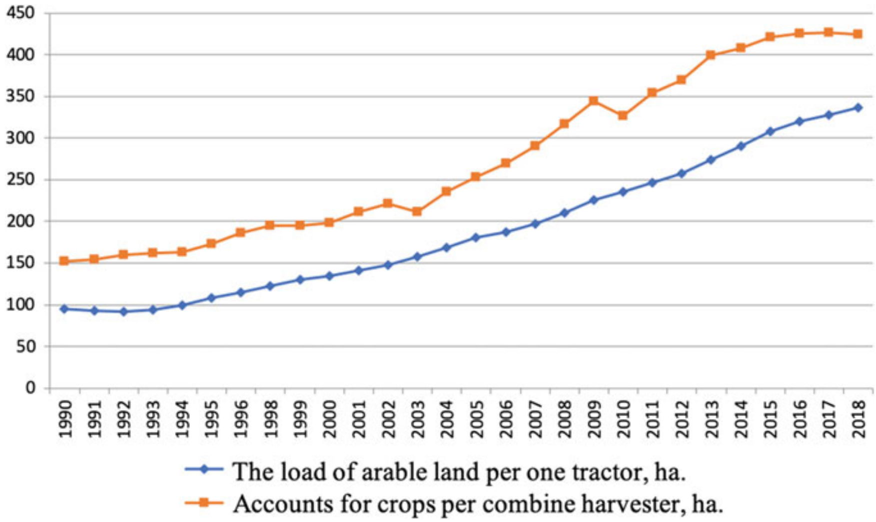

Fig. 3 The dynamics of the provision of agricultural organizations with tractors and combine harvesters in the Russian Federation, the load per unit of equipment, hectares. *Source* Compiled by the authors according to the Rosstat data [2]

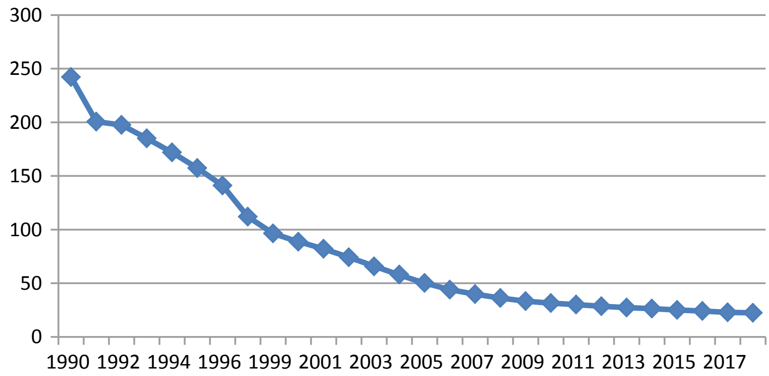

Fig. 4 The dynamics of the availability of milking devices and aggregates in farms of all categories in the territory of the Russian Federation, thousand units. *Source* Compiled by the authors according to the Rosstat data [2]

The areas of forage crops underwent the greatest reduction. They decreased from 44,608 ha in 1990 to 16,342 ha in 2017, which is primarily due to a reduction in the number of cattle from 57 million heads in 1990 to 18.3 million heads in 2017, including cows from 20.6 million heads to 8.0 million goals. This was one of the main reasons for the decrease in the number of milking devices and units (Fig. 4).

3.2 The Results and Pace of the Implementation of the Technical Modernization Subprogram

The budget appropriations provided for the implementation of the departmental project "Technical modernization of the agro-industrial complex" of the direction (subprogram) "Technical modernization of the agro-industrial complex" in 2018 amounted to ₽ 10,000 million in accordance with the federal law on the budget for 2018. Compared with the volume of budget allocations envisaged for the implementation of the direction "Technical modernization of the agro-industrial complex" in 2017, the volume of budget allocations is reduced by ₽ 5700 million (36%). As of January 1, 2019, the federal budget funds were actually used by 100% (₽ 10,000 million) (Table 2).

As a measure of state support for the technical and technological modernization of agriculture and updating the equipment fleet, subsidies are provided budget to manufacturers of agricultural equipment at the expense of the federal to reimburse the costs of manufacturing equipment sold to agricultural producers at a discount in the amount and according to the list approved by the Government of the Russian Federation, Decree of the Government of the Russian Federation of December 27, 2012 No. 1432 "On the approval Rules of granting subsidies to producers of agricultural machinery" (hereinafter—Regulation No. 1432).

Table 2 The expenses of the federal budget for the implementation of the relevant areas (subprograms), ₽ million

Name	2017 г		2018 г		Deviation, %	
	Plan	Fact	Plan	Fact	From the level of 2017	From the planned value
Departmental project "Technical modernization of the agricultural sector"	15,700	15,699.8	10,000	10,000	64	0

Source Compiled by the authors based on statistics

In the process of implementing Regulation No. 1432 in 2018, 64 agreements on granting subsidies were concluded with 64 agricultural machinery enterprises of the Russian Federation by Russia's Ministry of Agriculture. Subsidies and discounts are presented for 3820 units of agricultural machinery.

17,639 units of agricultural machinery were sold (98.9% of the forecast value of the target indicator), including 1225 tractors, 3428 combine harvesters, 226 forage harvesters, and 12,760 units of other types of machinery.

Failure to achieve the forecast value of the target indicator is associated with the adoption of the Decree of the Government of the Russian Federation on September 12, 2018 No. 1085 "On amending the rules for the provision of subsidies to manufacturers of agricultural machinery," providing for an increase in the size of subsidized discounts to 25%, and for the Siberian, Far Eastern Federal Districts, Republic of Crimea, and Kaliningrad region of up to 30%.

The bulk of agricultural machinery was delivered to the Rostov, Altai, Volgograd, Stavropol, Saratov, Krasnodar, Orenburg, Voronezh, and Oryol regions and the Republic of Bashkortostan.

However, the technology was not sold in four constituent entities of the Russian Federation (seven constituent entities in 2017) (Table 3).

For 2013–2018, during the implementation of Regulation No. 1432, ₽ 44,057 million of subsidies were spent. 5055 tractors, 17,500 combine harvesters, and 1003 forage harvesters were delivered, taking into account other types of machines—71,711 units. In 2018, the manufacturers of agricultural equipment allocated subsidies to investments in the development of the main products in the amount of ₽ 1993.6 million and ₽ 487.4 million in the design and development of new types of agricultural machinery.

In 2018, the Ministry of Industry and Trade of Russia issued positive decisions to 70 manufacturers of agricultural machinery (7% less than in 2017).

In 2018 and early 2019, Regulation No. 1432 was amended in parts:

- agricultural machinery and equipment included in the list of Decree of the Government of the Russian Federation of August 1, 2016 No. 740 "On the determination

Table 3 Key performance indicators

Indicators	Years							
	2013	2014	2015	2016	2017	2018		
						Plan	Fact	Level of completion, %
The number of new agricultural machinery sold by agricultural machinery manufacturers to agricultural producers	765	3053	6405	17,483	26,366	17,842	17,639	98.9
Including: combine harvesters	515	1584	2195	3120	6658		3428	
Forage harvesters	20	69	106	260	322		226	
Tractors	37	191	979	1092	1531		1225	
Other types of equipment	193	1209	3125	13,011	17,855		12,760	

Source Compiled by the authors based on statistics

of functional characteristics (consumer properties) and the effectiveness of agricultural machinery and equipment" since 2021, there is a corresponding solution, confirmed by the positive results of tests conducted on machine-testing stations of the Ministry of Agriculture of Russia (Decree of the Government of the Russian Federation (December 14, 2018 No. 1555));

- the list of agricultural machinery of Regulation No. 1432 with machinery and equipment for flax cultivation was supplemented (Decree of the Government of the Russian Federation (January 18, 2019 No. 8)).

As of January 1, 2019, the state technical supervision authorities registered 387 thousand tractors (2.8 thousand less than the data as of January 1, 2018), 131.2 thousand combine harvesters (1067 more), and 14.7 thousand forage harvesters (108 less) (Table 4).

According to the state technical inspection authorities, the share of equipment manufactured more than 10 years ago has been increasing (Table 5). Thus, the share of tractors increased to 73.1% (in 2017—70.8%); the share of combine harvesters to 64% (in 2017—61.3%), and forage harvesters—to 66.4% (in 2017—62.8%).

According to the data of the constituent entities of the Russian Federation, in 2018, agricultural producers through all sales channels purchased 16,320 tractors and combines (which is 9.1% less than in 2017), including 10,463 tractors (5.2%

Table 4 Self-propelled vehicles in the agricultural sector registered with the state technical inspection bodies

Type of equipment	2017	2018
Total	591,787	592,409
Including: tractors	389,831	387,000
Combine harvesters	130,121	131,188
Forage harvesters	14,784	14,676
Other combines	9390	9574

Source Compiled by the authors based on statistics

Table 5 The main types of equipment, manufactured more than 10 years ago in the Russian Federation, %

Type of equipment	2017	2018
Tractors	70.8	73.1
Combine harvesters	61.3	64.0
Forage harvesters	62.8	66.4

Table 6 Acquisition of the main types of agricultural machinery, units

Type of equipment	2017	2018	2018–2017, %
Tractors	11,035	10,463	94.8
Combine harvesters	6221	5221	83.9
Forage harvesters	694	646	93.1

less than in 2017), 5221 combine harvesters (16.1% less than in 2017), and 646 forage harvesters (7.4% less than in 2017) (Table 6).

At the same time, the energy supply of agricultural organizations in 2018 amounted to 148.6 hp per 100 ha of sown area, which corresponds to the level of 2017 (149.4).

In order to stop the retirement of equipment, move on to increasing the fleet, and achieve estimated supply in the near future, agricultural organizations need to purchase 45 thousand tractors, 12 thousand tones of grain, and 2 thousand forage harvesters annually.

4 Discussion

Agriculture was recognized as one of the locomotives of the movement of the entire domestic economy, which provides an incentive for the development not only of agricultural producers but also related fields such as agricultural engineering.

Technical modernization is one of the measures for stimulating agricultural production, which, in turn, depends on both the profitability of enterprises and the possibility of selling agricultural products, and on the domestic and foreign demand which is expected to increase due to the steady growth of real citizen income, the growth of the level of pensions, and a halving of the poverty level, and to increase the export of agricultural products from $25 to $45 billion by 2024 [5].

Nevertheless, modern agricultural machinery is represented by energy-intensive, expensive machines, so the high rate of renewal of its fleet in farms with all forms of ownership is practically impossible without state support.

In 2018, regional development programs and development institutions (Rosagroleasing JSC and Rosselkhozbank JSC) contributed to the renewal of the fleet. Regional programs were in place in 63 constituent entities of the Russian Federation, providing for partial compensation for the cost of purchasing agricultural machinery and equipment (56 in 2017, 55 in 2016, 52 in 2015, 49 in 2014, and 39 in 2013), with total funding from regional budgets of ₽ 11.3 billion (₽ 10.2 billion in 2017, ₽ 10.1 billion in 2016, ₽ 10.0 billion in 2015, ₽ 8.8 billion in 2014, and ₽ 4 billion in 2013).

In 2018, Rosagroleasing JSC delivered 5474 units of agricultural and automotive vehicles under leasing conditions (39.6% higher than in 2017), totaling ₽ 17.65 billion (81.7% higher than in 2017), including 903 tractors and 1099 harvesters.

In accordance with the Federal Law of November 29, 2018, No. 459-FZ, "On the Federal Budget for 2018 and the Planning Period of 2019 and 2020," the authorized capital of Rosagroleasing JSC was increased from the federal budget by ₽ 4 billion.

In 2018, Rosselkhozbank JSC provided borrowers with loans for the purchase of agricultural machinery worth ₽ 12.9 billion (2.4% more than in 2017). For this money, agricultural producers purchased 796 tractors (8% of the total number of tractors purchased) and 781 combined harvesters (13.3% of the total number of grain and forage harvesters purchased).

5 Conclusion

Despite its problems, there are still positive trends in the technical modernization of agriculture in the Russian Federation, which is a direct consequence of the implementation of the State Program for the Development of Agriculture and the regulation of agricultural markets for raw materials and food. However, the structure of the fleet consists of a significant number of tractors, occurred over 10 years, and involved foreign production. The structure of the agricultural machinery market in the Russian Federation requires increasing social and state significance and further successful implementation of the subprogram of technical modernization of the agro-industrial complex.

References

1. FAOSTAT: Official website (2019). Retrieved from https://www.fao.org/faostat/en/
2. Federal State Statistics Service: Official website (2019). Retrieved from https://www.fedstat.ru/
3. Government of the Russian Federation: State program for the development of agriculture and regulation of agricultural products, raw materials and food markets for 2008–2012. Moscow, Russia (2012). Retrieved from https://www.consultant.ru/document/cons_doc_LAW_70205/
4. Government of the Russian Federation: State program for the development of agriculture and regulation of agricultural products, raw materials and food markets for 2013–2020. Moscow, Russia (2014). Retrieved from https://www.consultant.ru/document/cons_doc_LAW_155198/9ade4fe9b412322ae325034a6b9097851bf9ae85/
5. Government of the Russian Federation: The decision on amendments to the state program for the development of agriculture and regulation of agricultural products, raw materials, and food markets. Moscow, Russia (2019). Retrieved from https://mcx.ru/upload/iblock/f3f/f3f6ff955102d66d3c193d811170b975.pdf.
6. Ministry of Agriculture of the Russian Federation: Report on the preliminary results of the implementation in 2012 of the state program for the development of agriculture and the regulation of agricultural markets, raw materials and food for years. Moscow, Russia (n.d.). Retrieved from https://pandia.ru/text/78/161/68884-4.php
7. Polukhin, A.A.: The main directions of reproduction of the material and technical base of agriculture in Russia. AIC: Econ. Manag. **12**, 122–124 (2012)
8. Zhosan, A.A., Golovin, S.I., Mikhailov, M.R.: The structure and composition of the ICC in domestic agriculture. Tract. Agric. Mach. **6**, 3–4 (2008)

Case Studies: Sustainability and Innovation in Agricultural and Food Systems

On the Results of the Implementation of Key Indicators of the State Program for the Development of Agriculture (Based on Materials from the Belgorod Region)

Jeanne A. Bojchenko, Elena A. Golovaneva, and Anna V. Hanova

Abstract The general characteristic of the program of development of agriculture of the Belgorod region for 2014–2020 is considered in this paper from the point of view of the main indicators of an assessment of its implementation. The comparison of planned and reached main reporting indicators is carried out. Within the framework of our research, we analyzed the indicators capturing the development of agricultural production over five years. The research pays particular attention to the tendency of their change, focusing on the main results of the activities of agricultural enterprises of the Belgorod region in terms of gross and net profit. In addition, the authors analyze the profitability of sales and activities in general and the structure of state support. The analysis was carried out according to the main development indicators: the agricultural production index on farms of all categories to the level of the previous year, the crop production index, the livestock production index, the profitability of agricultural organizations, the average monthly wage in agriculture, and the labor productivity index. Not all planned key indicators have been achieved. The reasons for their underfulfillment and circumstances complicating the functioning of agricultural producers of the Belgorod region in modern conditions are analyzed and discussed by the authors.

Keywords Agricultural production · State support · Target indicators · Reproduction process · Sustainable development

J. A. Bojchenko · E. A. Golovaneva (✉)
Belgorod State Agrarian University, Belgorod, Russia
e-mail: GEA010481@yandex.ru

J. A. Bojchenko
e-mail: bja1981014@yandex.ru

A. V. Hanova
Federal Research Center of Agrarian Economy and Social Development of Rural Areas—All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: sunnyhedgehog@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_42

1 Introduction

The agro-industrial complex and its basic industry, agriculture, are part of the leading system-forming spheres of the economy of the Belgorod region, which form the agri-food market, the food and economic security of the region, and the labor potential of rural areas [8].

The positive development of agricultural production in the Belgorod region is the result of the consistent application of the program-targeted approach in the agricultural sector of the economy. In order to implement the activities of the state program in the field of agriculture, an agreement was made between the Ministry of Agriculture of the Russian Federation and the Government of the Belgorod region. This agreement fixes the values of the main target indicators of the program.

Financing under the current State Program for the Development of Agriculture for 2013–2020 [7] allows agricultural producers to receive additional and stable funds for technical and technological modernization of production and ensure sustainable development.

Key indicators of the state program are focused on the strategic priorities of sustainable development and comprise a significant part of the initial data, ensuring the continuity of the reproductive process in agriculture. This contributes to the timely harmonization of priorities and key indicators, thereby forming effective competitive production, quantitative and qualitative growth in the agricultural sector of the economy.

2 Materials and Methods

In order to unify organizational, economic, social, labor, and administrative legal processes, executive authorities pay special attention to the implementation of targeted state programs. The general ideology of budget support aimed at the result leads to the need to assess the degree of implementation of key indicators during their implementation. We have analyzed the main indicators of the implementation of the Program for the Development of Agriculture and Fisheries of the Belgorod region for 2013–2020 according to the target indicators laid down in the regional program. The study was conducted on the basis of departmental statistical data of the Territorial Authority of the Federal State Statistics Service for the Belgorod region and data from the consolidated accounting (financial) statements of agricultural organizations of the Belgorod region of various forms of ownership.

The objective of the study is to assess the implementation of key indicators of the State program based on the available information base and identify positive positions in the implementation of measures affecting the development of priority agricultural sectors, strengthen the material and technical base, increase the profitability of agricultural enterprises, develop and rational use of production and economic potential.

3 Results

The Belgorod region occupies a leading position in the development of agricultural production. This is evidenced by the growth rate of the main indicators of production activity (Table 1) over the years of the implementation of the State Program for the Development of Agriculture for 2013–2020 [3].

The production of gross agricultural products in the Belgorod region has a tendency to increase. In 2017, its size amounted to ₽ 143.3 billion, which is 32.0% higher than the 2013 level and 3.0% higher than the 2015 level. The growth rate of the gross output of the crop industry is outstripping the growth rate of the gross output of the livestock industry by 50.9% and 27.1%, respectively. A positive aspect is the increase in gross crop production. Thus, the gross harvest of crops in 2017 increased by almost 70% compared to 2013. This is due to an increase in the cultivated area by 62.8 thousand ha and an increase in productivity by 17.2 c/ha. The gross harvest of sugar beets has changed slightly.

The Belgorod region is one of the dynamically developing agro-industrial regions of Russia. A fundamental decision was made in the region on the import substitution of greenhouse vegetables with products of local producers by using the accumulated competencies in the development of pig-breeding and poultry clusters in 2012.

This decision was enshrined in the "Strategy for the socio-economic development of the region for the period until 2025," and in 2013, in the state program of the Belgorod region, "Development of agriculture and fish farming in the Belgorod region for 2014–2020." In this connection, there is a significant increase in the gross production of vegetables of greenhouses almost 2.5 times. The sown area of greenhouse vegetables increased by 305.1 thousand m^2, and productivity increased by 11.8 kg/m^2.

As for the gross production of the livestock industry, it is also worth noting the positive dynamics. Therefore, despite a significant reduction in the number of cows by 600 animals during the analyzed period, the gross milk yield increased by almost 20% and amounted to 4347.2 thousand centers in the reporting year. This is due to an increase in cow productivity by 21.2%.

A steady increase in the number of pigs and poultry is observed, by 12.7% and 11%, respectively, which led to an increase in the gross growth of pigs and poultry.

A comparative assessment of production indicators shows a high level of intensity of the agricultural sector of the Belgorod region [5].

During the study, it was found that the development of reproductive processes most dynamically proceeds in agricultural organizations, even though budget funds between the crop and livestock industry over the past five years have been distributed in favor of the latter. As for the funds allocated for the development of the plant growing industry, their share is extremely small [4]. The size and structure of state support in the industry is shown in Table 2.

As the calculations confirm, there is a difference between plant growing and animal husbandry. The bulk of budget support was concentrated in the livestock

Table 1 Key indicators of production activities of the agricultural sector of the Belgorod region for 2013–2017

Indicator	Years			Growth rate for 2017 to %	
	2013	2015	2017	2013	2015
The cost of gross agricultural output, ₽ billion	108.5	139.2	143.3	132.1	103.0
Incl. crop production	22.8	29.1	34.4	150.9	118.2
animal husbandry	85.7	110.1	108. 9	127.1	98.9
Sowing area, thousand ha					
– Grains	521	490	583	111.9	119.0
– Sugar beet	65	63	63	96.9	100
– Open field vegetables	2	2	2	100	100
– Greenhouse vegetables, th. sq. m	432	606	737	170.6	121.6
Gross harvest, th. centners					
– Grains	17,936	17,884	30,483	170.0	170.4
– Sugar beet	25,943	22,610	25,999	100.2	115.0
– Open field vegetables	66.8	81.3	75.8	113.5	93.2
– Greenhouse vegetables, th. sq. m	121.9	192.2	296.8	243.5	154.4
Productivity, c/ha					
– Grains	35.3	36.8	52.5	148.7	142.7
– Sugar beet	401	360	411	102.6	114.2
– Open field vegetables	411	523	377	91.7	72.1
– Greenhouse vegetables, th. sq. m	28.2	31.7	40	141.8	126.2
Livestock, thousand animals					
– Cows	60.9	58.7	60.3	99.0	102.7
– Young cattle	90.1	82	83.6	92.8	102.0
– Pigs	3150.5	3301	3550.4	112.7	107.6
– Young birds	39	43.2	43.3	111.0	100.2
Production volumes, th. c					
– Milk	3624	3684	4347	120.0	118.0
– Cattle growth	176.9	168.5	177	100	105.0
– Pigs growth	6510	7178	6987	107.2	97.3
– Birds growth	7282	8031	8224	112.9	102.4
Milk yield per 1 cow, kg	5949	6272	7211	121.2	115.0

Source Compiled by the authors according to statistics [2]

Table 2 Volumes and sectoral structure of state support for agricultural organizations of the Belgorod region for 2013–2017

Industry	2013		2015		2017		2017 as % to 2013
	₽ mln.	%	₽ mln.	%	₽ mln.	%	
Plant growing	1124	15.0	2760	37.6	1081	23.9	96.2
Animal husbandry	6391	85.0	4572	62.4	3442	76.1	53.9
Total agricultural production	7515	100	7332	100	4523	100	60.2

Source Compiled by the authors according to statistics [2]

sector in the reporting year, amounting to ₽ 3442.51 million, which is 76.1% of budget funds, and the level of state support tends to decrease.

The amount of state support for the development of the crop sector has a slight decrease of 3.9%, amounting to ₽ 1080.69 million in the reporting year [1, 9].

According to the Agriculture Development Program of the Belgorod region for the period until 2020, the dynamics of the development of agricultural production is inextricably linked with the formation and implementation of a set of measures aimed at supporting agricultural producers of the region.

Further, it is important to evaluate the indicators of entrepreneurial activity of agricultural enterprises of the Belgorod region for the period of implementation of the state program, from 2013 to 2017 (Table 3).

The data in the table indicate that the revenue in 2017 increased by 1.5 times compared to 2013; this result was influenced by two factors, rising prices and increasing volumes of agricultural products sold. The positive indicator was that the growth rate of sales revenue outpaced the growth rate of cost. With an increase in revenue, the gross profit of agricultural enterprises doubled, which represents the gross income of organizations, i.e., a significant part of the added value.

Table 3 Indicators of entrepreneurial activity of agricultural enterprises of the Belgorod region for 2013–2017 (₽ billion)

	2013	2015	2017	Growth rate in 2017, %	
				2015	2013
Sales revenue	161.8	245.5	247.4	100.8	152.9
Cost of sales	139.3	186.8	201.6	107.9	144.7
Gross profit	22.5	58.7	45.7	77.9	203.1
Profit on sales	15.7	49.7	35.1	70.6	223.6
Profit before tax	15.2	44.3	28.7	64.8	188.8
Net profit	14.6	44.1	28.3	64.2	193.8
Return on sales, %	9.7	20.2	14.2	–	–
Profitability of all activities, %	10.4	23.6	14.1	–	–

Source Compiled by the authors according to statistics [2]

Table 4 The implementation of the main indicators of the state program for the development of agriculture of the Belgorod region for 2013–2020

Indicators	Plan	Fact	Deviation (+;−), %, p.p.
The index of agricultural production in farms of all categories (in comparable prices), % to the previous year	101.8	100.2	−1.6
The index of crop production, (in comparable prices), % to the previous year	101.5	90.1	−11.4
The index of livestock production, (in comparable prices), % to the previous year	101.9	105.7	+3.8
Profitability of agricultural organizations (including subsidies), %	16.5	14.1	−2.4
The average monthly nominal wage in agriculture (for agricultural organizations not related to small businesses), ₽	25,000	32,495	+130%
The index of labor productivity, % to the previous year	104.0	102.0	−2.0

Source Compiled by the authors according to statistics [2]

Profit from sales in the reporting year amounted to ₽ 35.1 billion. It also tended to increase relative to the base year. The return on sales in 2017 was 14.2% against the base level of 9.7%, which means ₽ 14 of revenue per 100 rubles. The profitability of agricultural enterprises also increased by 3.7% [6].

Attention should be paid to changing these key indicators relative to 2015. Due to the fact that the growth rate of costs is higher than the growth rate of revenue from sales, as well as due to a sharp drop in prices on the grain and sugar beet markets in 2017 (an average of 16.4% for grain and 38.7% for sugar beets compared to the same period in 2015), agricultural enterprises of the Belgorod region reduced sales profit by 30%, resulting in a decrease in net profit of more than 35%. In this connection, there was a decline in profitability indicators.

The implementation of the program activities is based on the achievement of the levels of its main indicators. The main indicators in 2017 are presented in Table 4.

The table shows that the agricultural production index in farms of all categories compared to the level of the previous year amounted to 100.2% (against the planned value for the year, which was 101.8%), the crop production index amounted to 90.1% (with the planned value of 101.5%), the livestock production index amounted to 105.7% (with the planned value of 101.9%), the average monthly wage in agriculture was ₽ 32,495 (with the planned value of ₽ 25,000), which is almost 30% higher than the planned level.

4 Discussion

Failure to comply with the key indicator "Crop Production Index" is because in 2017, for a number of objective reasons, indicators of production of the most capacious items in the overall structure of production were formed below the 2016 indicators: sugar beets (35,030 thousand tons in 2016; 26,000 thousand tons in 2017), corn for grain (10,554 thousand tons in 2016; 6802 thousand tons in 2017), and sunflower (2845 thousand tons in 2016; 2254 thousand tons in 2017).

The failure to meet the key indicator for the production of sugar beets and as a consequence, the production of sugar beets is explained by the fact that there is currently a clear tendency in the region to reduce the area under crops of sugar beets that are influenced by the lack of growth in the domestic Russian sugar market [10].

The value of the profitability indicator of agricultural organizations in 2017 amounted to 14.1% (planned value of 16.5%).

Failure to fulfill the key value of the indicator—profitability of agricultural organizations—is also due to a sharp drop in prices on the grain market in 2017 (an average of −15.4%, compared to the same period in 2016). There is a positive trend in the livestock industry. Agricultural organizations of the region produced 4347 centners of milk, which is 14.3% higher than the previous year.

In 2017, the average milk yield per cow amounted to 7211 kg, which is 741 kg more than in the same period last year.

According to the results of 2017, despite a set of unfavorable external factors, the agricultural sector of the region showed resistance to unfavorable conditions for conducting agribusiness. The failure to meet the key indicator for the production of sugar beets and as a consequence, the production of sugar beets is explained by the aforementioned factors.

5 Conclusion

State support for the agricultural sector of the economy of the Belgorod region in the framework of adopted target indicators of the implemented strategy serves as a powerful lever of influence on the sustainable growth of agricultural production. Despite a number of factors that complicate the functioning of agricultural producers in modern conditions due to the disparity in prices on the grain market, as well as the lack of effective organizational and economic mechanisms for their reduction, the agricultural sector is developing dynamically. And it grows not only by the progressive growth of production profitability and productivity in general but also by quality, which positively affects the competitiveness of agricultural products. A high degree of competitiveness and efficiency of entrepreneurial activity of economic entities ensures an increase in the standard of living and material well-being of rural residents and in food and economic security in the region.

References

1. Bazovkina, E.A., Vashcheykina, Y.Y.: The role of the state in the development of the crop industry of the Belgorod region. In: Proceedings from: Management and Marketing Aspects of the Development of Agribusiness and Agri-Food Market. Voronezh, Russia (2016)
2. Belgorodstat.: Official website (2019). Retrieved from https://belg.gks.ru
3. Bozhchenko, J.A.: The mechanism for the implementation of economic interests in agricultural organizations (Dissertation of Doctor of Economics). Moscow, Russia: Russian Research Institute of Organization of Production, Labor, and Management in Agriculture (2014)
4. Golovaneva, E.A.: Economic incentives to improve crop production in agricultural organizations (Dissertation of Candidate of Economics). Moscow, Russia: Russian Research Institute of Organization of Production, Labor, and Management in Agriculture (2013)
5. Golovina, L.A.: On the conditions for the effective functioning of agricultural organizations in the Oryol region. Econ., Labor, Manag. Agric. **3**(28), 13–16 (2016)
6. Golovina, L.A.: The valuation of the effectiveness of entrepreneurship in the production of crop production (on the example of agricultural organizations of the Belgorod region). Bull. Rural. Dev. Soc. Policy **3**(19), 7–12 (2018)
7. Government of the Belgorod region: The decree on approval of the state program of the Belgorod region “development of agriculture and fish farming in the Belgorod region for 2014–2020” 439pp. Belgorod, Russia, 28 Oct 2013
8. Panin, A.V.: The effectiveness of the use of farmland in the subjects of the Central Federal District. Econ., Labor, Manag. Agric. **4**(9) (2011)
9. Reshetnyak, L.A., Zdorovets, Y.I.: The role of state support in the development of agricultural production in the Belgorod region. In: Zaksevskaya, E.V., Ryabov V.P. (eds.) Proceedings from: International Scientific-Practical Conference “Strategy for the Innovative Development of Agriculture in the Context of Globalization of the Economy”. Voronezh, Russia (2015).
10. Vashcheykin, I.V.: The current state of the public procurement market. In: Proceedings from: Economic Aspects of Organic Production. Belgorod, Russia (2018)

Directions and Efficiency of Innovative Development of Agricultural Enterprises

A. P. Sokolova and O. A. Sukhareva

Abstract It is proposed to develop a methodology for innovative development and adaptation of agroeconomics to modern external economic challenges. The authors present their classification of the areas of innovative industrial development and its determining factors, indicators, and criteria, reflecting the effectiveness of innovative transformations. A common methodology and private methods for assessing the level of development and efficiency of using the potential of agricultural production in the region and individual producers are developed. On the basis of the developed methodology, the priority directions of the innovative development of the region's agroeconomy based on the example of the Krasnodar Territory are substantiated.

Keywords Agroeconomics · Innovative development · Determinants of innovative development · Innovative potential

1 Introduction

The main aspect of the development of the modern economy is innovation, which should guarantee the steady progressive development of the enterprise, industry, region, and state as a whole and become a kind of springboard for entering a new round of development. In the agro-industrial complex, which plays a key role in solving the global state problem—ensuring the country's food security—innovations should become the basis for the quantitative and qualitative growth of all elements of the agricultural sector. The competitive advantage of agricultural enterprises, which are based on innovations, is formed through the creation of an innovative process that is difficult to reproduce by competitors, which results in goods that have real advantages compared to market counterparts. However, the high cost of innovative processes, the duration of their implementation, uncertainty, and a high level of risk

A. P. Sokolova (✉) · O. A. Sukhareva
Kuban State Agrarian University named after I. T. Trubilin, Krasnodar, Russia
e-mail: prof.sokolova@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_43

necessitate a sound approach to the selection of areas of innovative development. The aim of the paper is to study the theoretical aspects of the innovative development of agricultural enterprises, find its determinants, and formulate a strategy for the scientific and technological development of the agro-industrial complex.

2 Materials and Methods

The methodological basis of the study was to review and analyze the works of domestic and foreign researchers on the innovative development of the economy at the level of individual economic entities, regions, and states, the formation of various approaches to assessing the innovative potential of industries, and the assessment of the effectiveness of innovation.

The study used systemic and logical approaches; the following research methods were used: monographic, method of expert assessments, logical, and method of scientific abstraction.

3 Results

The innovative development of any economic system is based on the general principles and patterns inherent in this economic process. With regard to sectors of the economy, the essence of innovation does not have fundamental differences. However, the content and directions of the innovation process in them may vary due to the characteristics of industries. Innovation activity in the agricultural sector is carried out constantly and continuously, which determines the formation of the innovation process as a regularly and sequentially alternating system of measures for conducting research and development, creating and mastering their results in all areas of agricultural production. The innovation process in the agro-industrial complex has specific properties due to the characteristics of agriculture as a branch of production. Innovative activity in the agro-industrial complex can be characterized as a set of sequentially carried out actions for creating new or improved agricultural products (or products of their processing), improved technology, and organization of production based on the use of the results of scientific research and development [2].

As both foreign and domestic practice show, for sustainable and productive innovative development, an enterprise needs a whole range of determinants. Identification and study of their influence is an important scientific and practical task from the point of view of increasing the effectiveness of the innovative policy of the enterprise. Along with the general determinants of development that are characteristic of any type of activity, innovative development involves a number of specific determinants: the scientific and technical potential of the enterprise as an opportunity to develop and adapt product and process innovations, the availability and use of the pilot facilities of the enterprise, the presence of completed R&D, licenses and patents, product structure, and threats to functional and (or) technological substitution [4].

In the study, we separately highlighted the determinants of the innovative development of agricultural organizations arising from the characteristics of the manufacturing industry, the modern global challenges facing agriculture, and the scenarios of innovative development of the country and its sub-sector (Fig. 1).

In order to assess the contribution of scientific and technological progress to the growth of production in the agricultural sectors, materials of agricultural enterprises of the Krasnodar region were studied. The calculation was performed by the index method using the software. The calculation results for the main crops are presented in Fig. 2 and Table 1. From the data, it follows that the production of winter cereals in the study period is relatively stable. The volume of production increased on average by 23% per year. The growth of production is ensured entirely thanks to the biological, technical, and technological factors of scientific and technological progress and increased efficiency in the use of existing technologies. Manufacturers of the sub-sector, due to its strategic importance for the country's food security, can accumulate investments and knowledge, new technologies, and modern equipment, which expresses an increase in the overall productivity of production factors in the industry by 26.5% over the studied period [5].

A difficult situation has developed in the production of sunflowers for grain. Due to adverse climatic conditions and due to the deterioration of market conditions in the market, a decrease in production volumes by an average of 0.1% per year continues in the sub-sector. At the same time, the negative value of the indicator of changes in the overall productivity of production factors indicates the degradation of the technologies used. The complexity of the cultivation technology and the dependence of sugar beet productivity on climatic conditions determined the unstable indicators of its production. However, during the study period, the use of modern technologies and best practices in the production process explains a 29% increase in the volume of crop production. The cumulative growth of vegetable production in the study period amounted to more than 55%, and the growth of the total productivity of factors of production amounted to 40%. Thus, the use of modern technologies and effective technological solutions explains the 60% increase in vegetable production.

Innovative development and management at all levels of management presuppose that the business is focused on achieving goals that are consistent with state strategic priorities [3]. In studying the promising areas of innovative development of agricultural organizations, we systematized the provisions of existing forecasts, strategies, and development programs. The Ministry of Agriculture of the Russian Federation developed and approved the forecast of the scientific and technological development of the agro-industrial complex of the Russian Federation for the period ending in 2030 (approved by the order of the Ministry of Agriculture of Russia No. 3, dated January 12, 2017) [1]. According to the forecast, in its development, the agro-industrial complex of Russia will face a number of economic, social, environmental, and technological challenges. Comparing these challenges with the existing

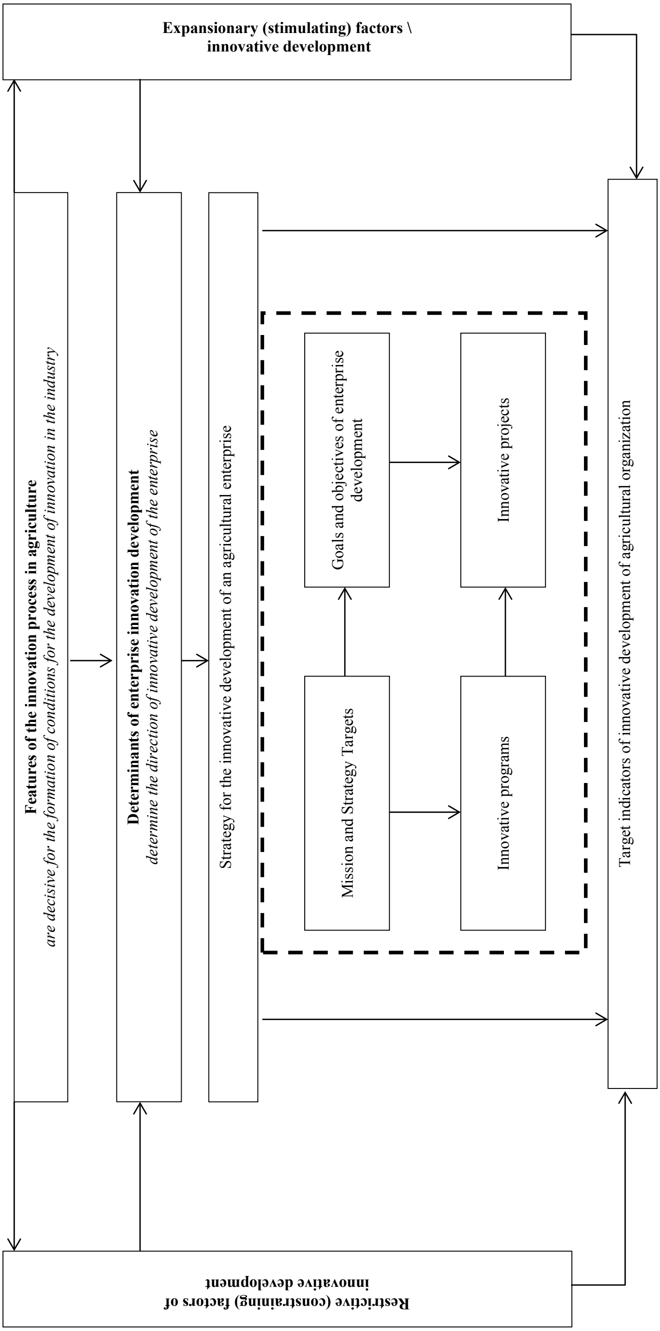

Fig. 1 Determinants and factors of innovative development in the formation of the strategy of the agricultural organization

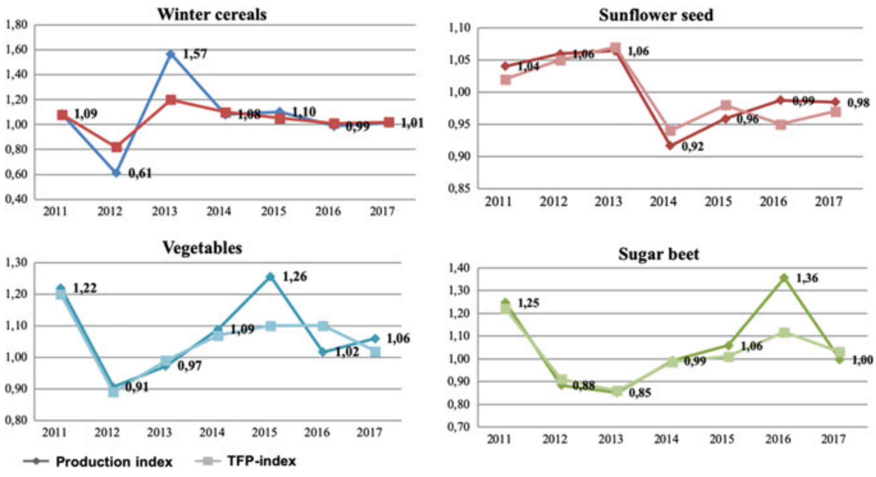

Fig. 2 The index of output and total productivity of factors of production of individual crops

Table 1 The assessment of the contribution of scientific and technological progress to the growth of production of selected crops in the period 2010–2017

Culture	Cumulative output growth, %	Cumulative TFP Growth, %	Share of TFP in output, %
Winter cereals	23.4	26.5	113.1
Sunflower seed	0.1	– 2.7	Negative value
Sugar beet	33	9.4	28.5
Indoor and outdoor vegetables	58.5	39.6	67.7

Source Developed by the authors

production, innovation, and scientific and technical potential of the Russian agro-industrial complex, the authors of the forecast developed two possible strategies for the innovative development of the agro-industrial complex—local growth and global breakthrough—differing in terms of prospects for entering the international market, development drivers, and framework macroeconomic conditions (Fig. 3).

4 Conclusion

The experience of economically developed countries proves that the innovative activity of economic entities is the key to ensuring economic security and reducing the

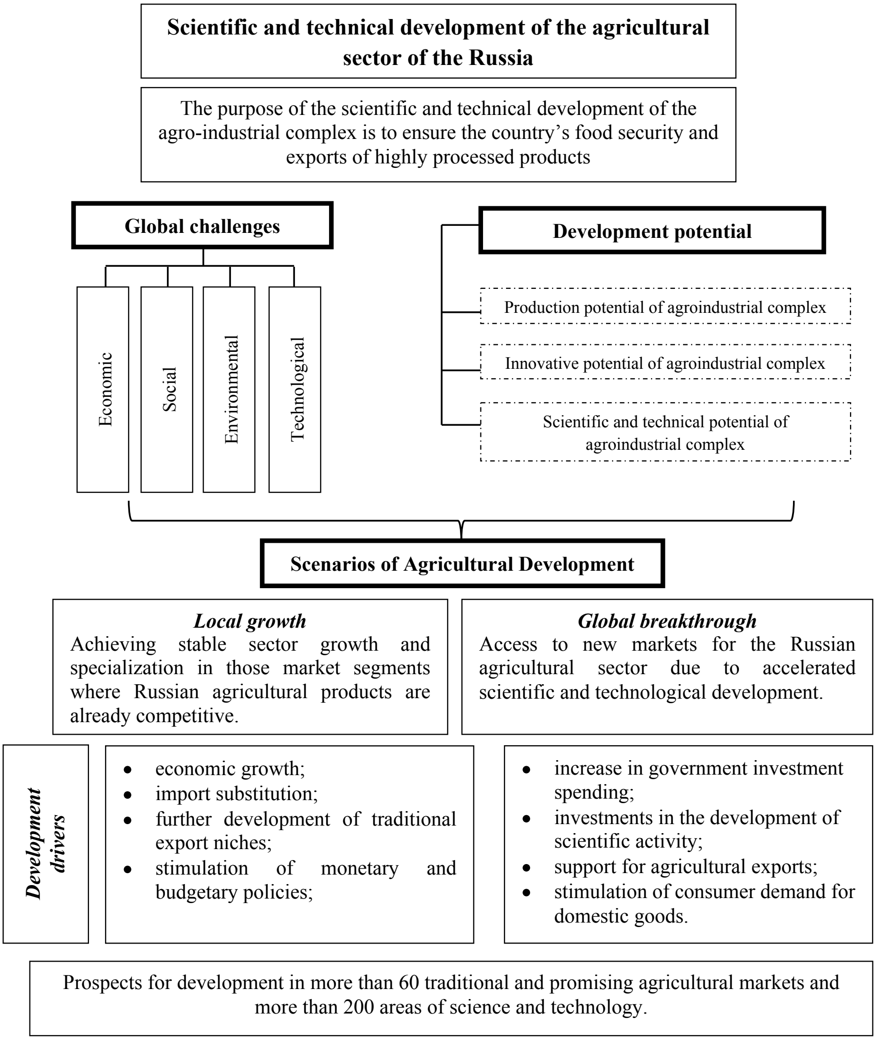

Fig. 3 Scenarios of scientific and technical development of the agro-industrial complex of Russia

dependence of national economies on world market conditions. The domestic agricultural producers set ambitious strategic goals not only in the field of import substitution and ensuring food security of the country, but also the conquest of promising international markets. Such a qualitative "leap" in the system of production and sale of agricultural products is possible only due to the transition to the innovative path of development of agricultural enterprises.

The revealed features of the innovative development of agricultural enterprises allowed us to conclude that an important scientific and practical task is to identify the specific determinants of the innovative development of agricultural organizations.

In the study, the existing system of determinants of innovative development of the enterprise is supplemented by determinants that are characteristics of agricultural enterprises and stem from the characteristics of the production industry, modern global challenges facing agriculture, scenarios of innovative development of the country, and the place of the industry in it.

The conceptual prerequisite for the innovative development of an enterprise is its innovative potential, which is expressed not only in the availability and level of development of the industry's production forces, but also in the ability of manufacturers to efficiently use resources using the best manufacturing practices and technologies. The analysis of the dynamics of crop production output indicators using the index of the total productivity of production factors allowed us to conclude that there is a significant innovative potential that industry manufacturers can further realize in the process of developing the agricultural sector of the region as a whole.

Scientific and technological development of the agro-industrial complex is possible according to two alternative scenarios. The current level of innovative activity of agricultural organizations indicates a low demand for innovative production technologies, especially of domestic development. Therefore, it is necessary to stimulate the innovative activity of agricultural organizations, including from the state. Supporting agricultural producers' initiatives will allow them to enter international markets with products with a high share of processing and better quality.

References

1. Ministry of Agriculture of the Russian Federation.: The forecast of scientific and technical development of the agro-industrial complex of the Russian Federation for the period up to 2030. (January 12, 2017 No. 3). Retrieved from https://issek.hse.ru/data/2017/05/03/1171421726/Prognoz_APK_2030.pdf (2017)
2. Novoselov, S.V., Mayurnikova, L.A.: Theoretical innovation: research and innovation activity and innovation management. GIORD, St. Petersburg (2017)
3. Sokolova, A. P. (2018). Innovation as a factor in increasing the efficiency of the agro-industrial complex. The results of research work for: Proceedings from: The 73rd Scientific Conference of Teachers, pp. 573–574. Kuban State Agrarian University, Krasnodar, (2017)
4. Sukhareva, O.A., Naydenova, A.V.: Perspective directions of innovative development of the agro-industrial complex of Russia. Colloquium J. **4–4**(28), 71–73 (2019)
5. Trubilin, A.I., Bershitsky, Yu.I., Tyupakov, K.E., et al.: Theory, methodology, and results of the substantiation of the directions of innovative development of agroeconomics of the Krasnodar Territory. Kuban State Agrarian University, Krasnodar (2018)

The Assessment of Diversification of Food Export of Russia

Natalia A. Yakovenko and Irina S. Ivanenko

Abstract The paper focuses on the analysis of the current state and features of international trade in agricultural products and foodstuffs, conducting an assessment of Russian food export diversification possibilities. The authors conduct a comparative analysis of the dynamics and structure of world and Russian food exports for 2012–2016. The general and specific features of the world and Russian food exports development are identified. The diversification necessity of the country's agri-food export food basket as a factor of agri-food complex sustainable economic growth in the context of global challenges and restrictions is substantiated. The authors argue that export diversification, high value-added products export growth will contribute to the sustainable development of the agricultural and food industries. Relying on the indicators of the export diversification index, the authors demonstrate a low level of Russian food exports diversification and weak exports structural changes in recent years. An export-oriented strategy for the Russian agri-food complex development is proposed, suggesting the strengthening of the domestic producers' competitive positions in the world food market traditional segments and the formation of competitive advantages for conquering new markets. The research clearly shows that effective development of food exports and the improvement of its product structure is impossible without state support. The main directions for improving the structure of food exports in the Russian Federation are also proposed.

Keywords Export · Diversification · Food market · Agri-food complex

N. A. Yakovenko · I. S. Ivanenko (✉)
Institute of Agrarian Problems of the Russian Academy of Sciences, Saratov, Russia
e-mail: ivanenko.ol@yandex.ru

N. A. Yakovenko
e-mail: Yana0206@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_44

1 Introduction

The deepening of integration processes has led to an increase in the influence of the role of international trade on the development of the agri-food complex. The dynamics of growth and diversification of accelerated trade and the geographical direction of exports and imports have changed. World trade in agricultural products and food in 2016 increased by 5.2% compared to 2012. Structural shifts are taking place in the dominant sources of competitiveness. Developed countries, using the latest technologies, high labor productivity, effective management, free access to investments, lobbying for the interests of large national companies, and influence on world regulatory institutions are the main subjects of international trade and are strengthening their competitive positions in the world food markets. In these conditions, the export potential of the agri-food complex of Russia, its development trends, and its implementation features require further in-depth study.

The development of interstate trade in the framework of absolute and comparative advantage models was studied by representatives of the classical theory. Currently, in economic theory, the issues of expanding world economic relations are closely interconnected with the problems of the formation and development of competitive advantages [1].

In the institutional economy, the country's export opportunities and their implementation in the world market are studied in terms of the functioning efficiency of the institutions established in the country, the institutional environment, and the institutional structure of the economy.

An objective trend in the modern development of national economies is a change in the relationship between internal and external factors, a deepening of their interdependence and interconnection, and an increase in the influence of external factors. The processes of globalization lead to a deeper involvement of economies and their individual sectors in the world economy, focusing on external markets for products. The increase in the share of exports remains an important factor in the strengthening and development of national economies. In modern conditions, high export growth rates are important as well as diversification and quality structure. The works of Guerson et al. revealed the dependence of the growth of gross domestic product on export specialization and its structure [2]. Studies by Sachs and Warner proved a direct correlation between low economic growth and the country's raw material export specialization [3]. Hammels and Klinow revealed a high differentiation of export of developed countries [4]. The export of goods with high added value and a diversified export structure allow developed countries to maintain the stability of the economy and respond flexibly to global challenges.

However, the dynamic changes that are taking place in the world and national food markets and the particularities of the realization of the export potential of the agri-food complex require further in-depth study [5, 6].

The aim of the study is to assess the dynamics and structure of food exports in Russia and identify trends in the development of world food exports and the export of the agricultural products and food of Russia.

2 Materials and Methods

The assessment of the dynamics and structure of food exports was carried out on the basis of data from the Organization for Economic Co-operation and Development (OECD). The OECD includes 36 countries, which account for about 60% of the world's gross domestic product (GDP). The aggregated indicators of the trading activity of the agro-food industry sectors were investigated. The available base is presented by data on export volume in million US dollars for 2012–2016 for 23 types of industries. The calculations were carried out at current prices, so the results of the calculations are affected by the influence of inter-regional price differentiation, which cannot be leveled out on the basis of the available statistics.

The analysis of changes in the product structure of food exports was carried out on the basis of the export diversification index, which was calculated by the formula:

$$S_j = \frac{\sum_i \left|h_{ij} - h_i\right|}{2}$$

where h_{ij}: the share of product i in total food exports of country j, h_i: the share of product i in global food exports.

The index characterizes the deviation of the commodity structure of a country's exports from the structure of world exports. It is used, as a rule, to determine differences in the structure of foreign trade of countries whose exports are quite versatile. This index takes values from 0 to 1. Values close to 1 indicate that the country's export structure deviates from that of the world; that is, it is slightly diversified.

3 Results

The formation of the modern global food market is influenced by globalization processes. The growing demand for food and the deepening international division of labor stimulate the development of world markets for agricultural raw materials and food. However, studies have shown that the global food market is developing unstably. The export of world agricultural raw materials and food products in value terms from 2012 to 2016 has increased (Table 1).

In the context of product groups, the largest export growth was recorded in crops. In 2016, grain export volume increased by almost 8 times compared to 2012. The leading grain exporting countries are the USA, Canada, Russia, France, Australia, Germany, Ukraine, Romania, Kazakhstan, and India.

Growth in exports was observed in the market of fruits, potatoes, and vegetables. Over the study period, world fruit exports grew by 16.1%, and potatoes and vegetables grew by 19.5%.

Positive dynamics for the study period were observed in the world market of high value-added products obtained as a result of the processing of agricultural raw

Table 1 The dynamics of world food export and food export of the Russian Federation, in current prices, in %

Indicator	2013	2014	2015	2016
World food export	105.8	103.5	95.0	101.2
Food export of Russia	102.8	126.5	84.8	79.4
The share of food exports of the Russian Federation in world food exports	1.12	1.01	0.85	0.97

Source Developed by the authors

materials. In 2016, exports of food industries increased by 1.3% compared to 2012. The main exporters of high value-added products are industrialized countries: the USA, Germany, the Netherlands, Italy, and China. Therefore, an important direction of Russia's export strategy should be the development of deep-processing of agricultural raw materials, the production of high value-added products, and their promotion on the world market.

For the period 2012–2016, negative trends were observed in livestock market segments. Exports in the group of live animals decreased by 12%, while meat and edible meat offal decreased by 3.7%. Exports for a group of dairy products, eggs, honey, and animal products decreased by 11.6%.

The development of the export potential of the agri-food complex of Russia is focused on increasing the competitiveness of the complex in the context of the expansion and deepening of world economic relations. The study revealed the general and specific trends in the development of the export of Russia's agricultural products and food were revealed. In separate segments of the food market, multidirectional trends in the development of Russian and world exports were shown (Table 2).

Globalization processes have intensified the competition in global food markets. The consequence of increased competition was the volatility, instability, and unpredictability of world food markets. Under these conditions, there was an increase in protectionism and an expansion of methods of state support for national food producers, especially in developed countries. In recent years, both economic and administrative barriers to entry into world food markets have been actively used. The introduction of sanctions and restrictions in 2014 significantly affected the export of Russian food. In 2016, Russia's total food export in value terms decreased by 12.5% compared to that in 2012, with a positive trend in global exports [7].

Over the study period, there has been an increase in Russian exports to nontraditional segments of the food market for the country. According to the OECD, out of 23 industry groups, exports of meat and edible meat offal have grown significantly. Compared with those in 2012, Russian exports of meat and meat products in 2016 increased by 3.7 times with a negative trend in global exports. In terms of the assortment of the commodity group of meat and edible meat offal, the largest shares of exports were meat and edible offal from poultry meat—53.4%, edible offal from red meat—20.1%, and fresh, chilled, or frozen pig meat—18.7%.

Table 2 Dynamics of world food export and food export of Russia by selected products, 2016 in % to 2012

Code	Industries	World export	Russian export
1	Live animal	87.98	196.07
2	Meat and edible meat offal	96.30	365.00
3	Fish, crustaceans, mollusks, aquatic invertebrates	106.59	120.31
4	Dairy products, eggs, honey, and animal products	88.45	74.64
5	Products of animal origin, not included in other categories	89.16	15.60
6	Living trees, plants, bulbs, roots, flowers, etc	92.19	231.76
7	Vegetables and some edible root crops and tubers	119.49	140.81
8	Edible fruits, nuts, peel of citrus fruits, melons	116.05	71.08
9	Coffee, tea, mate and spices	99.45	103.96
10	Cereal crops	795.58	89.68
11	Grinding products, malt, starches, inulin, wheat gluten	98.00	1539.41
12	Oilseeds, oleagic fruits, grains, seeds, fruits, etc	95.04	129.03
13	Varnishes, resins, vegetable juices, and extracts	50.65	232.09
14	Vegetable plaiting materials, vegetable products not included in other categories	109.91	71.91
15	Animal, vegetable fats and oils, cleavage products, etc	81.32	97.87
16	Meat products, fish and seafood products not included in other categories	93.68	72.45
17	Sugar and sugary confectionery	84.13	88.00
18	Cocoa and cocoa preparations	109.12	86.61
19	Cereals, flour, starch, dairy products	112.63	119.43
20	Supplements for vegetables, fruits, nuts, etc	102.79	129.45
21	Different food products	114.28	10.48
22	Drinks, spirits and vinegar	98.26	85.07
23	Wastes of food industry, animal feed	93.66	87.54

Source Compiled by the authors

In recent years, Russia has been a world leader in the export of grain crops. Russian grain exports in 2018, according to Rosstat, amounted to 54.8 million tons, which is 1.1% more than it was in 2017. In 2018, compared with 2012, grain exports grew 2.4 times (by 32.3 thousand tons). Over the study period, the average annual growth rate amounted to 18.9%. High competition in the grain market was reflected in lower prices. Therefore, in value terms, Russian grain exports from 2012 to 2016 decreased by 10.3%.

The growth of Russian exports in physical terms is observed in almost all segments of the grain market. In 2016, Russian wheat exports exceeded US exports by 5.5%

or 1.3 million tons, in 2017, by 21% or 5.8 million tons, and in 2018, almost doubled or 21.5 million tons [8].

In 2018, Russia ranked third in barley export after France and Australia. Barley export growth over the study period amounted to 17.3% or 5.44 million tons. The export of rye in 2018 compared to 2012 increased to 262 thousand tons, or 6.8 times. However, this segment of the grain market is unstable, as rye is in limited demand in the world market. Deliveries go only to Europe in conditions of shortage of production. In 2018, Russia ranked second in rye export, second only to the traditional producer: Poland. Russia occupies a leading position in the buckwheat market. Exports of buckwheat in 2018 compared with 2012 increased by 55%.

In recent years, Russia has been among the top ten exporters of oats and the top five world exporters of legumes. Russian oat exports in 2018 compared with 2012 increased 3.8 times. The export of legumes in physical terms over the same period increased to 1358 thousand tons, or 8.2%. According to Rosstat, the export of legumes in 2018 amounted to $325 million in value terms, which is 21% lower than in 2017.

The developed countries of the world over the past twenty years have been forming a new, innovative economy, which is based on intellectual resources, knowledge, and information. In the future, it will determine the main trends in the development of the world economy and the place of each country in the international division of labor. The innovative development strategy of the Russian agri-food complex is focused on the adaptation of Russian producers to the changes occurring in the global agri-food system. Active development is expanding and deepening global value chains. Innovative shifts in the structure of social production should form the prerequisites for the diversification of Russian exports. Currently, there is a low level of diversification of food exports in Russia (Fig. 1).

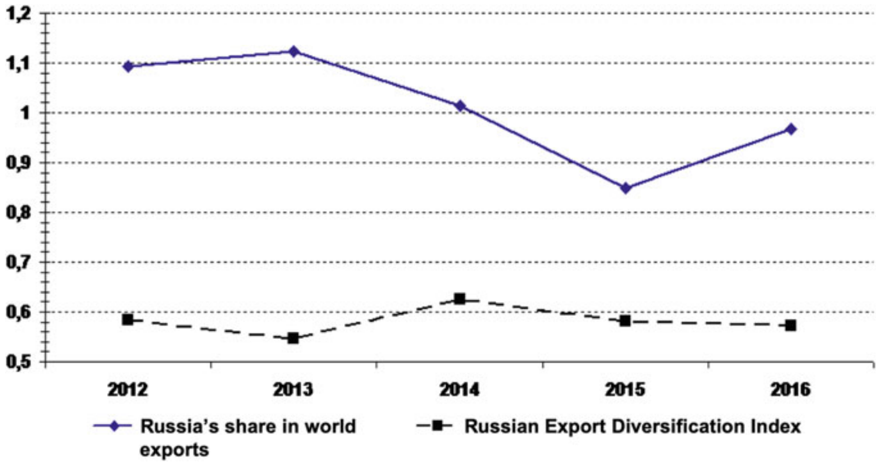

Fig. 1 The dynamics of the diversification index of food exports in Russia and Russia's share in food exports, in %

The processes of globalization and integration form the advantages arising from the deepening of specialization; the rapid dissemination of scientific, technical, economic knowledge, management experience; the expansion of investment in innovation; the internationalization of financial and information markets; the reduction of transaction costs; and changes in the economic structure. Diversification of food exports in modern conditions involves the restructuring of the agri-food complex—aimed at accelerating the development of industries with high added value, the development of new innovative types of production—increasing the share of high-tech products, deepening the division of labor.

4 Discussion

In 2012–2016, conflicting changes occurred in the structure and dynamics of Russian food exports. Russia is stepping up its participation in international trade in agricultural products. This is largely due to a change in the priority of import substitution for the development of an export-oriented strategy, the formation of an export promotion system, and financing activities to expand the geography of access of Russian products to foreign markets.

The general trend is to increase the volume of food exports in Russia in physical terms and its decline in value terms [sentence confusing/unclear]. This is due to the instability of the global food market, which is reflected in high price volatility. This decrease is understandable in the face of a slowdown in the global economy and growing geopolitical tensions; as a result, demand for goods is falling. In 2015–2016 there was a significant drop in prices in traditional markets for Russia—the grain, oil, and oilseed markets. At the same time, Russia strengthened its competitive position in these markets, increasing export volumes in real terms. In the study period, there was an increase in the export of potatoes, vegetables, fruits, and meat products based on the growing competitiveness of Russian producers. At the same time, in addition to traditional buyers, deliveries to the countries of the Middle East, Asia, and Latin America increased.

As many experts note, positive trends have been formed on the basis of short-term factors—the food embargo, the ruble devaluation, and increased government support for agricultural producers. Russia has significant potential for integration into the global agri-food system. State agri-food policy should be aimed at the formation of long-term factors of competitiveness growth.

In the context of globalization and the deepening international division of labor, the effectiveness of implementing an export-oriented development strategy for the Russian agri-food complex depends on the search for and formation of new competitive advantages—the introduction of resource-saving and innovative technologies, focus on intensive development methods, equalization of imbalances in the development of industries, diversification of exports, and creation of new types of markets and high-value-added products [9].

5 Conclusion

In the context of stagnation and decline in industrial production, Russian agri-food complex sectors maintain positive dynamics, which is largely due to the expansion of state support for the agricultural sector. Further growth in agricultural production and food will bring domestic agri-food markets closer to their capacity limits. Therefore, the long-term potential for economic growth of the agri-food complex is associated with an increase in the volume of food exports and its diversification.

Diversification of food exports is a multi-level process, including territorial, sectoral, and product aspects. Export diversification is closely linked to production diversification. Flexible and quick response to dynamic changes in the world and domestic food markets, adaptation to modern challenges and risks of globalization, and the formation of sustainable competitive advantages of Russian producers require structural modernization of the Russian agri-food complex.

Food export diversification strategy should be aimed at strengthening competitive positions in traditional segments of the Russian food market and expanding the range of goods that can be exported. Diversification of food exports and the launch of competitive products to foreign markets make the agri-food complex more stable in relation to external influences and make rational use of natural, labor, production, investment, and other resources.

References

1. Giidchenko, A.A., Salnikov, V.A.: Dynamics of Russia's competitive positions on external markets. Probl. Forecast. **6**, 81–101 (2013)
2. Guerson, A., Parks J., Torrado, M.: Export structure and growth: a detailed analysis for Argentina. Word Bank Policy Research Working Paper Series, 4237 (2007)
3. Sachs, J.D., Warner, A.M.: The curse of natural resources. Eur. Econ. Rev. **45**, 827–838 (2001)
4. Hummels, D., Klenow, P.: The variety and quality of a nation's exports. Am. Econ. Rev. **95**(3), 704–723 (2005)
5. Akhramovich, V.S.: Methodical approaches to assessing the export potential of the agri-food industry. Agrarian Econ. **8**, 43–50 (2014)
6. Mozol, A.V.: Principles of formation and use of export potential in the agroindustrial complex. In: Materials from III International Scientific-Practical Conference: Economic Growth of the Republic of Belarus: Globalization, Innovation, Sustainability, Minsk, Republic of Belarus, BSEU (2010)
7. International Trade Centre.: Retrieved from https://tradecompetitivenessmap.intracen.org/TP_TP_CI.aspx?RP=004&YR=2016 (2016)
8. Russian Export Center.: The Development of General and Non-oil Exports of Russia in 2016. Retrieved from https://www.exportcenter.ru/international_markets/russian_exports/ (2016)
9. Yakovenko, N.A., Rodionova, I.A., Ivanenko, I.S., Kireeva, N.A., Sukhorukova, A.M.: Export potential as the competitiveness indicator of the agri-food complex. Int. J. Eng. Technol. **7**(4.38), 654–658 (2018)

Problems of Innovation Management in the Agricultural Sphere

Sergey V. Laptev, Faina V. Filina, and Inna L. Litvinenko

Abstract The purpose of the paper is to justify an economic mechanism that stimulates the development of innovations in agriculture and related industries with a relative decrease in the budget financing for these purposes. The study is based on statistics on innovation, labor productivity, as well as on the results of economic analysis of the driving forces and factors of agricultural growth. As a result of the study, it was found that the key factors affecting the development of innovative processes in agriculture are the level of provision of organizations with financial resources, the level of motivation for innovation, the ability of organizations to create innovations or replicate the innovations already created. It was determined that the predominant part of innovations formed in agriculture is replicative, based on borrowing other people's experience and knowledge. As recommendations, the expediency of regulating the ratio of basic prices for agricultural products and marginal prices for goods and services of related industries of the agro-industrial complex is justified. The introduction and maintenance of such ratios will reduce the need for agriculture in price subsidies and state subsidies, stimulate the development of competition. More than that, it will promote the development of competition and innovation processes throughout the agro-industrial complex, as well as increase the rate of growth of labor productivity.

Keywords Innovation · Agricultural sector · Innovation financing · Competition · Entrepreneurship · Labor productivity · Economic development

S. V. Laptev
Financial University under the Government of the Russian Federation, Moscow, Russia

Plekhanov Russian University of Economics, Moscow, Russia

F. V. Filina (✉)
Moscow International University, Moscow, Russia
e-mail: nauka-ags@mail.ru

I. L. Litvinenko
Moscow State University of Humanities and Economics, Moscow, Russia

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_45

1 Introduction

There is no clear and consistent concept in innovation management in Russia. In practice, purely liberal approaches are often criticized. In theory, they often dominate, as the forms and methods of innovation management in different segments of the economy are formed spontaneously. Theories of planning and state regulation of the economy, which clearly define and justify the best set of methods of regulation and self-regulation for the state as a whole and each individual segment of the economy, have not yet been created.

In the absence of other concepts, one often turns to the liberal one, which asserts that the strongest motivations in the economy are related to private property rights and that consistent market-based distribution of economic resources creates the best combinations of resource use, while state intervention in these processes through planning or regulation only worsens the effectiveness of the combinations formed.

In practice, the spontaneous development of events increasingly creates various kinds of problems in which the state has to intervene.

The purpose of this paper is to justify agricultural innovation management methods that combine elements of market self-regulation and state planning and regulation.

2 Materials and Methods

The study is based on the study of domestic and international experience, the use of statistics, proactive research, and development.

As a method of innovation management, the approach to regulating the ratio of basic prices for agricultural products and services and prices for final products from agricultural raw materials is justified.

3 Results

The long-term development of innovations is influenced by three main factors: the availability of financial resources for organizations, the ability of organizations to innovate or effectively apply innovations already created by others, and motivation for innovation.

In the short and medium term, the innovation activity of organizations is influenced by many other factors: the achieved technological level of organizations, the possibility of increasing labor productivity and other resources based on existing technologies, the availability of innovative infrastructure, the presence of organizations professionally engaged in scientific research in agriculture, the established

Table 1 The proportion of organizations implementing technological innovations in the reporting year, for some types of economic activity

Indicator	Russian industry classification system (OKVED) code	2017
In total, of them by type of economic activity		7.5
Annual crops cultivation	01.1	3.9
Perennial crops cultivation	01.2	2.6
Seedling cultivation	01.3	2.1
Animal husbandry	01.4	2.9
Auxiliary activities in the field of crop production and post-harvest processing of agricultural products	01.6	2.1
Industrial production, of which		9.6
Mining	B	5.1
Manufacturing industries, of which	C	13.7
Manufacture of computers, electronic and optical products	26	31.9
Manufacture of electrical equipment	27	24.5

Source Compiled by the authors based on statistics [3]

forms of state innovation support, etc. Let us first evaluate the general level of innovative activity of agricultural organizations (Table 1). If we summarize the shares of agrarian organizations innovatively active in all considered types of innovative activity, we get the share of agrarian organizations engaged in innovations: 13.6%.

If we take into account that some organizations are innovatively active in several areas of activity at once, this figure will need to be reduced.

In general, the level of participation of agricultural organizations in innovation is not lower than the average for the economy and higher than the average, for example, in the extractive industries. However, most of the innovations carried out in Russia, as, indeed, in other economies of the world, are new only on the scale of our country. In the statistics of the developed advanced production technologies for 2017, the Russian agricultural organizations do not appear.

This means that the innovation activity of agricultural enterprises, taken into account in the statistics of our country, essentially represents the transfer of advanced foreign technologies, equipment, and organization of production to Russian soil. The effectiveness of this kind of innovation is not associated with long cycles of scientific research. It is a manifestation of not innovative, but replicative entrepreneurship; that is, entrepreneurship oriented not to create new ones, but to replicate already known solutions [1].

Table 2 Labor productivity index for Russia and some sectors of the Russian economy (by sections of the OKVED) in 2003–2017

Sectors of the economy	2003–2007	2008–2014	2003–2014	2015	2016	2017	2015–2017
In the whole economy	107.4	101.95	103.8	98.9	100.2	101.9	100.98
Agriculture	103.9	103.65	103.8	104.2	102.6	105.3	104.0
Manufacturing	106.2	102.5	103.9	100.7	102.4	100.7	101.3
Mining	105.8	102.56	103.9	99.5	100.3	101.6	100.46
Production and distribution of electricity, gas, water	101.5	100.08	100.6	100.4	101.1	100.1	100.5
Wholesale and retail trade	108.2	101.8	104.4	93.4	96.4	101.7	97.1
Construction	109.2	100.8	104.4	100.8	102.3	97.6	100.21
Hotels and restaurants	105.8	100.1	102.4	98	94.1	103.5	98.5
Transport and communications	107.3	101.86	104.1	100.3	100.8	100.0	100.7

Source Compiled by the authors based on statistics from the section "National Accounts. Labor productivity" [6]

The effectiveness of innovative activities not of the world (international), but mainly of the domestic level (related to the manifestations of replicative entrepreneurship) can be estimated based on the dynamics of labor productivity in the corresponding sector of the economy (Table 2).

In agriculture, employee productivity is influenced by conflicting forces. On the one hand, the possibility of acquiring modern means of production necessary to achieve high productivity is significantly constrained by the monopolistic practice of representatives of related sectors in the agricultural sector, pumping out a significant part of the added value created by them from the agricultural pricing mechanism. The remaining financial resources are not enough for ensuring normal reproduction, and only state support allows agricultural enterprises to acquire the minimum necessary assets.

On the other hand, a high level of competition in agriculture forces agricultural producers to exert every effort and use every opportunity to ensure the production of competitive products.

The minimum level of state support from the state does not allow agricultural enterprises to intensively update equipment and technology at a low level of profitability, even taking into account state support; therefore, in 2003–2007, the growth rate of labor productivity in agriculture was lower than the average for the economy. It was higher in 2008–2014. The average growth rate of labor productivity in the entire economy and in agriculture for the period from 2003 to 2014 is approximately not changing, at 103.8%.

Table 3 Domestic current expenditure on research and development by type of work in the agricultural sector, million rubles

Years	Internal current R&D costs	Including by type of work		
		Basic research	Applied research	Development
2010	8887.6	4766.0	2582.5	1539.1
2011	10,455.8	5283.0	3396.1	1776.7
2012	10,855.5	4587.4	4503.9	1764.1
2013	11,504.7	4845.9	4651.5	2007.3
2014	13,156.2	7536.0	3703.3	1916.9
2015	13,664.1	8047.6	3699.0	1917.4

Source Compiled by the authors based on statistics from the section "Science and Innovation. Technological development of industries" [4]

The leading growth of labor productivity in the period 2008–2014 was provided by agricultural holdings: their share in the commodity production of agriculture in this period increased from a quarter to about half. Agroholdings, due to their intersectoral nature and high production volumes, can more successfully resist the dictates of monopolists from agribusiness sectors related to agriculture. They have higher indicators of labor productivity than independent agricultural enterprises. Thus, in 2016, commodity production per employee in agricultural holdings amounted to an average of ₽2583.3 thousand, and in independent agricultural organizations ₽256.2 thousand [8].

Due to the growing role of agricultural holdings and government funding of research in the agricultural sector, in recent years, the total cost of research has increased significantly (Table 3). For the analyzed period (2010–2015), total research and development costs increased by 53.7%, and basic research costs increased by 68.9%.

Moreover, most agricultural producers have very modest incomes. How can we maintain a high level of competition and its positive impact on the production process in agriculture and yet maintain the income of the majority of normally working agricultural producers at a level that allows us to modernize outdated technologies and systematically engage in innovation radically? Related parties (producers, processors of agricultural raw materials, transport companies, trade networks, banks, suppliers of fuel and lubricants, electrical workers, and mineral fertilizers) receiving monopolistically high incomes are not in a hurry to invest them in the modernization of their own production and have quite moderate and even modest indicators in the field of innovation.

4 Discussion

Innovations in various sectors of the economy, including agriculture, to a large extent, depend on the share of the cost of research and development in relation to the gross product in this industry. In agriculture in 2015, this share amounted to 0.43% if we refer the data from Table 3 to the value of GDP produced in agriculture in 2015. In the same year, the share of research and development costs in relation to GDP as a whole in the Russian economy was 1.1%; in 2017, it was −1.11% [2]. The total funding for research and development costs in agriculture from all sources, including universities and research organizations, amounted to ₽20,507.9 million in 2015 and to ₽22,158.8 million in 2017 [7]. If we single out the share of agricultural organizations in this total amount of expenses, then it will turn out to be very small: ₽568.5 million rubles in 2017 [5] or 2.6%.

The business organizations' own costs of research and development are not tangible unless they are specialized research organizations and universities. Nevertheless, by the share of the costs of research and development in relation to the gross product of the corresponding organization, one can judge the motivation of the corresponding organization for scientific research and innovation.

In Table 4, data on research and development costs by type of economic activity in the Russian Federation are correlated with GDP production indicators for the corresponding types of activity in 2017.

In the context of other industries, agricultural organizations' motivation to participate in research activities looks quite good. Of the activities listed in the table, the best situation is only in the field of education and professional research. Nevertheless, it is obvious that business organizations have insufficient motivation to research. A mechanism is needed to motivate business organizations to research and development. It is advisable to motivate the owners of organizations to innovate primarily through the mechanism of taxation of their income—this way, the state will solve two problems by mobilizing additional income to finance research and encouraging

Table 4 The share of research and development costs financed by organizations of the relevant sectors of the economy in relation to the GDP of the same industries in 2017 in %

Some types of economic activity	R&D costs in relation to industry GDP
Agriculture, forestry, hunting, fishing, and fish farming	2.6
Mining	1.2
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.89
Financial and insurance activities	0.0013
Transportation and storage	0.0026
Professional, scientific, and technical activities	22.13
Education	2.97

Source Calculated by the authors according to official statistics owners (founders) to spend more of their income on these goals. The state spends significant funds to support the incomes of agricultural producers and to stimulate innovation, including in sectors of the economy related to agriculture. In agriculture, the combination of a high level of competition and a low level of income—due to the monopolistic practice of allied enterprises—limits the possibilities of modernizing outdated technologies and intensifying innovative activities and forces the state to maintain high budget expenditures to support farmers. In related industries, excessive monopolistic practice limits the positive influence of competition to such an extent that manufacturers do not really want to engage in innovation or the modernization of outdated technologies. The state is forced to spend substantial funds to stimulate innovation in these sectors.

Thus, the policy of regulating income levels in the agro-industrial complex sectors can bring bilateral benefits to society. On the one hand, a slight increase in the income level of most agricultural producers can intensify their activities to modernize production and develop innovative processes, as they will be better provided with resources, while government spending on supporting farmers can be reduced. On the other hand, the income level of allied monopolists can be reduced. The state can, by its actions, increase competition among agricultural companies related to agricultural producers. As a result, this will strengthen the process of modernization of obsolete technologies and the development of innovation in all sectors of the agro-industrial complex, while reducing the level of state financial support for these processes and keeping prices for agricultural products at a moderate level.

5 Conclusion

In order to stimulate the growth of labor productivity and the development of innovative processes in agriculture and throughout the agro-industrial complex while reducing the volume of state budget financing, it is advisable to introduce in the agro-industrial complex control over the ratio of prices for agricultural products and goods and services of sectors of the economy related to agriculture. The state, through the procurement price system, should play a decisive role in setting basic prices for agricultural products, which allow well-functioning enterprises to cover current costs and finance investments. In order to prevent unjustified overpricing of final products from agricultural raw materials, limit ratios of prices for final products and services as a percentage of base prices should be introduced. If the actual prices of the final product or service exceed the marginal ratios, this should lead to an increased profit tax rate for the violator.

Such economic regulation of prices can, on the one hand, better than at present, protect the incomes of agricultural producers from redistribution in favor of allied monopolists and reduce, and, in the future, possibly even exclude price subsidies for agriculture. On the other hand, the prices and income of agricultural allies in the agricultural sector will be less dependent on their monopoly power, and, therefore, their motivation to lower costs and innovate (in relation to which price ratios may be more favorable) will increase.

References

1. Baumol, W.: Microtheory of Innovative Entrepreneurship. Gaidar Institute Publishing House, Moscow (2013)
2. Federal State Statistics Service: Sections: Science and Innovation. Domestic research and development costs in the Russian Federation. Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/science/# (2017a)
3. Federal State Statistics Service: Sections: Technological Development of Industries. Science, innovation and advanced manufacturing technology. The proportion of organizations implementing technological innovations in the reporting year, in the total number of organizations surveyed in the Russian Federation, by type of economic activity (in 2017). Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/science (2017b)
4. Federal State Statistics Service: Sections: National Accounts. Labor productivity. Labor productivity index for Russia and the main sectors of the economy of the Russian Federation (by sections of OKVED) in 2003–2014. Retrieved from www.gks.ru/free_doc/new_site/vvp/vvp-god/pr-tru.xlsx (2017c)
5. Federal State Statistics Service: Sections: Science and Innovation. Internal costs of research and development on socio-economic goals in the Russian Federation. Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/science/# (2017d)
6. Federal State Statistics Service: Sections: National Accounts. Labor productivity. Labor productivity indices in the economy of the Russian Federation in 2015–2017 (in % to the previous year). Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/# (2017e)
7. Federal State Statistics Service: Sections: Science and Innovation. Internal costs of research and development by type of economic activity in the Russian Federation. Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/science/# (2017f)
8. Shagayda, N.I., Uzun, V.Y.: Drivers of Growth and Structural Changes in Russian Agriculture. Delo, Moscow (2019)

The Sectoral Approach to the Analysis of the Effectiveness of Agro-industrial Integration in the Context of Innovative and Sustainable Development of the Agricultural Sector

Tatiana V. Baibakova, Elena V. Rodionova, and Olga V. Zakirova

Abstract In the modern agro-industrial production of many countries, one of the leading trends is the consolidation and integration of economic entities. Therefore, an important task of agroeconomic science is the justification of methodological approaches to the analysis of the effectiveness of integration processes. The paper focuses on the developed methodology for assessing the effectiveness of the integrated formation of the agro-industrial complex, which is based on a sectoral approach to the location of organizations within it. The proposed methodology makes it possible to identify the economic performance of the current financial and investment activities of the integrated formation as a whole, as well as of individual sectors and enterprises that are part of it. In contrast to the existing approaches, the authors propose to use both private and general performance indicators of current financial and investment activities, presented in the form of coefficients for individual enterprises, sectors, and integrated formation as a whole. The paper provides a phased assessment of the effectiveness of the functioning of two integrated formations before and after the integration process. As a result of applying the proposed methodology, it was revealed that the process of integration has a different impact on the economic performance of different activities of integrated formation, which may be caused by the size of investment in the modernization and expansion of production capacities of enterprises of the sectors of production and processing of agricultural raw materials.

Keywords Sectoral approach · Agro-industrial integration · Integrated formation · Current activity · Financial activities · Investment activities

---

T. V. Baibakova (✉)
Vyatka State University, Kirov, Russia
e-mail: baybakova@vyatsu.ru

E. V. Rodionova · O. V. Zakirova
Volga State University of Technology, Yoshkar-Ola, Russia
e-mail: rodionovaev@volgatech.net

O. V. Zakirova
e-mail: Myholding@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_46

1 Introduction

Building on the Rio + 20 outcome, sustainable development is a holistic concept with four interconnected dimensions: economic development (including ending poverty), social inclusion, environmental sustainability, and good governance [8]. Sustainable productivity will require policy coherence and innovation. Necessary policy reforms include those that increase support for the rural sector by improving infrastructure, strengthening capacities along value chain actors, and stimulating innovation [7].

An integrated role, which has spread in many countries, plays a significant role in achieving the goals of innovative and sustainable development of the agro-industrial complex. The Russian agro-industrial complex is also characterized by the development and diversity of integration processes, the complexity of their forms, the increasing impact of integration on the rates of economic growth, the competitiveness of agri-food products, and the development of the export potential of the industry [5]. Theoretical and practical aspects of agro-industrial integration were discussed in the works of many domestic and foreign scientists, however, a number of important issues of the implementation of integration processes remain insufficiently studied. One of these issues is the development of methodological approaches to the analysis of the effectiveness of agricultural integration and the activities of integrated formations [4, 6]. Conducting such studies, forming an information base for improving integration processes, making effective state and corporate management decisions, seems relevant and practical.

2 Materials and Methods

When analyzing the economic efficiency of integrated agricultural production, the authors propose to use a sectoral approach [1], which positions organizations that participate in integrated agricultural production into three sectors (production of agricultural raw materials, processing of agricultural raw materials, and sales of products made from agricultural raw materials) and three types of activities (current (operational), financial, and investment).

Based on the sectoral approach, a matrix of types of activities and relations between organizations is built from the integrated formation of the agro-industrial complex, in which intra-sectoral, intersectoral, operational, financial, and investment relations can be distinguished (Table 1).

This matrix of relationships and activities is used to develop an algorithm for assessing the effectiveness of an integrated formation and assessing the development of decisions for achieving a sustainable integrated formation of agribusiness.

In this three-sectors approach to building an integrated formation, the agricultural raw materials production sector is represented by agricultural organizations. The raw materials processing sector includes industrial enterprises, and the sales sector

Table 1 A matrix of relationships and activities between organizations within the integrated formation of the agro-industrial complex

Connection	Goal / Result	Current activity	Financial activities	Investment activities
Intra-sectoral connection	Goal	Cost optimization associated with the core business of organizations	Organization of financial flows between organizations of one sector	Participation in investments in the operational activities of other organizations in the same sector
	Result	Information and resources exchange between organizations Improving financial and economic performance within the sector	An ability to influence operational and financial activities within the sector Income generation within the sector	Earning income from participation in investing in the operating activities of other organizations
Cross-sectoral connection	Goal	A transfer of raw materials from the manufacturing sector to the processing sector The transfer of finished products from the processing sector to the sales sector	Organization of financial flows between the organizations of different sectors	Participation in investing in operating activities of organizations in various sectors
	Result	An increased revenue for the organizations in different sectors	An ability to influence the operational activities of the organizations in different sectors. Earning additional income from organizations in different sectors	Receiving fees for participation in the operational activities of organizations in various sectors

includes its own trade organizations and trade networks, which form a complete technological chain (a closed cycle) within the integrated formation of agriculture.

The method of the economic evaluation of the efficiency of the integrated formation of agriculture is based on the calculation and comparison of performance indicators of current, financial, and investment activities at the level of organizations, sectors, and integrated formation of agriculture as a whole [2]. The method is presented in the following stages:

1. The calculation of private indicators of the efficiency of using the resources of organizations, sectors, and the integrated formation of the AIC as a whole.
2. The calculation of general performance indicators of current, financial, and investment activities of organizations, sectors, and the integrated formation of the AIC complex as a whole.
3. The calculation of an integral indicator of the effectiveness of the organization, sector, or the integrated formation of the AIC.
4. The evaluation of the implementation of the economic conditions for the effectiveness of the functioning of the organization, sector, or the integrated formation of the AIC.

In the proposed methodology, the key indicator characterizing the effectiveness of the integrated formation is the profitability of sales, presented in the form of a seven-factor multiplicative model (Table 2).

An integrated indicator of the effectiveness of the functioning of an organization, sector, or integrated formation of the AIC (EF), showing the value of the economic return on invested funds, is calculated as the product of general indicators of the effectiveness of activities:

$$\text{EF} = \text{Эca} \times \text{Эfa} \times \text{Эia}$$

Table 2 The indicators for assessing the effectiveness of the functioning of the integrated formation of the agro-industrial complex

Type of activity	Private Indicators of the Resource Efficiency	Formulas for calculating overall performance indicators
Current activity	F_o —return on assets; C_{ca}—ratio of current assets turnover	$E_{ca} = F_o \times C_{ca}$
Financial activities	C_{fd}—ratio of financial dependency; R_{bc}—return on borrowed captal;	$E_{fa} = C_{fd} \times R_{bc}$
Investment activities	F_i—capital intensity; E_{ca}—capacity ratio of current assets; C_i—capital-output ratio	$E_{ia} = F_i \times E_{ca} \times C_i$

Source Developed by the authors

The integrated formation of the agro-industrial complex is effective if the following condition is met:

$$Eca > Эfa > Эia.$$

The materials of the study conducted with the use of the proposed methodological approach included information on the results of the activities of two integrated groups: CJSC "Kirov Dairy Plant" (Kirov, Kirov Region) and JSC "Moloko" (Shakhunya, Nizhny Novgorod Region). The integrated formation of the CJSC "Kirov Dairy Plant" is represented by three sectors:

1. the sector of the production of agricultural raw materials ("Agrofirm Progress" LLC, "Chudinovskaya Agrofirm" LLC, "Podgortsy Agrofirm" LLC, "Kolkovskaya Agrofirm" LLC, "Bobino-M Agrofirm" LLC, "Korshik Agrofirm" LLC, "Agrofirm Mukhino" LLC, "Agrofirm New Way" LLC, "Agrofirm Prigorodnaya" LLC);
2. the sector of the processing of agricultural raw materials (CJSC "Kirov Dairy Plant");
3. the sector of the sales of agricultural commodities (LLC "Vyatushka Trading House").

The integrated formation of JSC "Moloko" is represented by three sectors:

1. the sector of the production of agricultural raw materials ("Rus" JSC, "Progress" JSC, "Lastinskoye" JSC, "Izhevskoye" JSC, "Khmelevitsy" JSC);
2. the sector of the processing of agricultural raw materials ("Milk" JSC);
3. the sector of the sales of agricultural commodities (LLC "Shahun milk Trading house").

3 Results

The results of the economic evaluation of the functioning efficiency of the integrated formation sectors of the CJSC Kirov Dairy Plant prior to the integration are presented in Table 3.

The results of the economic evaluation of the functioning efficiency of the integrated formation sectors of the CJSC Kirov Dairy Plant after the integration are presented in Table 4.

After integration, the maximum operational efficiency is observed at Agrofirma Mukhino, LLC (29%). In the context of sectors, the maximum efficiency of functioning is observed in the sector of processing of agricultural raw materials: 41%.

Assessing the aggregate performance indicators, it can be concluded that the integration had a positive effect on the functioning of the organizations and enterprises of the integrated formation of the CJSC Kirov Dairy Plant (Table 5).

Table 3 The performance indicators of the functioning of the sectors of the Kirov Dairy Plant CJSC before the integration

Indicator groups	The name of indicators	The sector of production of agricultural raw materials	The sector of processing of agricultural raw materials	Sector of sales of the products made from agricultural raw materials
Partial indicators of effective use of resources	Capital productivity	1.05	1.36	4.65
	Turnover ratio of current assets	1.34	7.28	3.87
	Financial dependency ratio	0.24	0.82	0.78
	Return on borrowed capital	0.62	0.13	0.46
	Capital intensity	0.95	0.74	0.22
	Capacity ratio of current (current) assets	0.75	0.14	0.26
	Capital-output ratio	1.87	0.07	0.57
General performance indicators	Current activity	1.41	9.87	17.99
	Financial activities	0.15	0.11	0.36
	Investment activities	1.33	0.01	0.03
Integral performance indicator		0.28	0.01	0.19
Actual performance condition		Эca > Эfa < Эia	Эca > Эfa < Эia	Эca > Эfa < Эia

Source Calculated by the authors

Despite the growth of the integral indicator of operational efficiency from 6 to 37%, the condition of operational efficiency is not fulfilled. The main reason is the inefficiency of the sector of production of agricultural raw materials. First, this is due to the inefficient formation of the price of raw milk sold to the sector of processing of agricultural raw materials. As a result, the sector of production of agricultural raw materials receives less profit, which ultimately leads to a low level of return on borrowed capital and low efficiency of financial activities of the integrated formation of agriculture.

The results of the economic evaluation of the efficiency of the sectors of the integrated formation of JSC "Moloko" before the integration are presented in Table 6, and those after the integration, in Table 7.

Table 4 The performance indicators of the functioning of the sectors of the Kirov Dairy Plant CJSC after the integration

Indicator groups	The name of indicators	The sector of production of agricultural raw materials	The sector of processing of agricultural raw materials	Sector of sales of the products made from agricultural raw materials
Partial indicators of effective use of resources	Capital productivity	1.18	2.08	12.79
	Turnover ratio of current assets	1.42	8.87	4.50
	Financial dependency ratio	0.65	0.47	0.83
	Return on borrowed capital	0.31	1.09	0.67
	Capital intensity	0.85	0.48	0.08
	Capacity ratio of current (current) assets	0.70	0.11	0.22
	Capital-output ratio	0.97	0.80	0.62
General performance indicators	Current activity	1.68	18.45	57.59
	Financial activities	0.20	0.51	0.56
	Investment activities	0.58	0.04	0.01
Integral performance indicator			0.41	0.35
Actual performance condition			Эca > Эfa < Эia	Эca > Эfa < Эia

Source Calculated by the authors

After the integration, the agricultural raw materials sector functions more efficiently. This is due to the implementation of more intensive investment activities. However, the level of efficiency of other sectors is changing in a negative direction.

The summary performance indicators of the integrated formation of JSC "Milk" are presented in Table 8.

The integration process had a positive impact on the implementation of the investment activities, as well as on the economic performance of the integration of the AIC as a whole.

Table 5 The summary indicators of the effectiveness of the functioning of the organizations of CJSC "Kirov Dairy Plant" before and after integration

Indicator groups	The name of indicators	Before integration	After integration
Private indicators of the effective use of resources	Capital productivity	1.28	1.87
	Turnover ratio of current assets	3.34	4.50
	Financial dependency ratio	0.27	0.51
	Return on borrowed capital	0.41	0.87
	Capital intensity	0.78	0.54
	Capacity ratio of current (current) assets	0.30	0.22
	Capital-output ratio	0.54	0.83
Overall performance	Current activity	4.28	8.39
	Financial activities	0.11	0.45
	Investment activities	0.13	0.10
Integral performance indicator		0.06	0.37
Actual performance condition		Эca > Эfa < Эia	Эca > Эfa < Эia

Source Calculated by the authors

4 Discussion

Thus, the authors propose, within the framework of a sectoral approach to the integrated formation of the agro-industrial complex, to divide the activities of agricultural organizations and industrial enterprises into three sectors and three types of activities. The sectors are: the agricultural production sector, the agricultural processing sector, the sales sector of the products made from agricultural raw materials. And the types of activities are current, financial, and investment activities. This approach allows to build a complete closed-loop process chain, rationally allocate resources, and evaluate the efficiency of their use within the integrated formation of the agro-industrial complex.

For the sustainable development of the integrated formation of the agro-industrial complex, it is necessary to monitor the performance indicators of current, financial, and investment activities constantly at the level of organizations, sectors, and the integrated formation of the agro-industrial complex as a whole. For monitoring, a technique is proposed according to which the key indicator characterizing the effectiveness of the integrated formation of the agro-industrial complex is the profitability of sales, presented in the form of a seven-factor multiplicative model. The calculations of economic indicators made by the methodology allow us to determine

Table 6 The performance indicators of the sectors of JSC "Moloko" before the integration

Indicator groups	The name of indicators	The sector of production of agricultural raw materials	The sector of processing of agricultural raw materials	Sector of sales of the products made from agricultural raw materials
Partial indicators of effective use of resources	Capital productivity	0.70	4.43	145.62
	Turnover ratio of current assets	1.00	2.82	14.17
	Financial dependency ratio	1.15	3.89	4.79
	Return on borrowed capital	0.04	0.03	0.16
	Capital intensity	1.43	0.23	0.01
	Capacity ratio of current (current) assets	0.99	0.36	0.07
	Capital-output ratio	1.18	0.14	0.01
General performance indicators	Current activity	0.70	12.49	2063.44
	Financial activities	0.05	2.22	0.77
	Investment activities	0.25	0.01	0.00001
Integral performance indicator			0.28	0.016
Actual performance condition			Эca > Эfa < Эia	Эca > Эfa < Эia

Source Calculated by the authors

the fulfillment/non-fulfillment of the condition Eca > Efa > Eia and draw a conclusion about the efficiency level of functioning of the organizations, sectors, and the integrated formation of the agro-industrial complex as a whole.

Based on the results of an economic assessment of the effectiveness of the functioning of the integrated formation of the agro-industrial complex, it is proposed to use the algorithm for developing the decisions necessary to achieve its sustainable development. The algorithm offers a multivariance of actions, the choice of which is based on the comparisons with each other of the calculated values of the performance indicators of the current, financial, and investment activities of the integrated formation of the agricultural sector.

Table 7 The performance indicators of the sectors of JSC "Moloko" after the integration

Indicator groups	The name of indicators	The sector of production of agricultural raw materials	The sector of processing of agricultural raw materials	Sector of sales of the products made from agricultural raw materials
Partial indicators of effective use of resources	Capital productivity	0.74	6.20	160.63
	Turnover ratio of current assets	1.09	3.86	12.13
	Financial dependency ratio	1.16	1.64	0.91
	Return on borrowed capital	0.09	0.03	0.13
	Capital intensity	1.35	0.16	0.01
	Capacity ratio of current (current) assets	0.92	0.26	0.08
	Capital-output ratio	1.05	0.18	0.05
General performance indicators	Current activity	0.81	23.93	1948.44
	Financial activities	0.10	0.05	0.12
	Investment activities	1.30	0.01	0.0004
Integral performance indicator			0.012	0.009
Actual performance condition			Эca > Эfa < Эia	Эca > Эfa < Эia

Source Calculated by the authors

5 Conclusion

The development of the integration processes in the agricultural sector contributes to the unification of agricultural organizations and industrial enterprises in the integrated formation of the agro-industrial complex with the aim of improving the quality parameters of agricultural raw materials, optimizing the costs of its production, and implementing price regulation for agricultural raw materials.

Large-scale production in the agro-industrial integrated formation provides its advantages in comparison with other forms of agribusiness organization: financial opportunities for acquisition of modern technologies and equipment; an increase of productivity of agricultural production; obtaining more favorable conditions for loans; the ability to influence the competitive situation due to a considerable share of the market; a possibility of deliveries to large distribution networks; higher activity in the implementation of an innovative way of production development; opportunities to attract highly qualified specialists, etc. [5].

Table 8 The summary performance indicators of the organizations of JSC "Moloko" before and after integration

Indicator groups	The name of indicators	Before integration	After integration
Private indicators of the effective use of resources	Capital productivity	4.31	3.99
	Turnover ratio of current assets	3.53	3.58
	Financial dependency ratio	2.31	1.35
	Return on borrowed capital	0.04	0.06
	Capital intensity	0.23	0.25
	Capacity ratio of current (current) assets	0.28	0.28
	Capital-output ratio	0.17	0.24
Overall performance	Current activity	15.21	14.28
	Financial activities	0.09	0.08
	Investment activities	0.011	0.017
Integral performance indicator			0.019
Actual performance condition		Эca > Эfa < Эia	Эca > Эfa < Эia

Source Calculated by the authors

As a result of the combination of these advantages, a synergistic effect arises—the appearance of the integrated formation of new systemic properties that ensure the growth of the overall effect to a value greater than the sum of the effects of its participants acting separately [3].

The study showed that the establishment of intra-sectoral, intersectoral, operational, financial, and investment ties between organizations and enterprises contributes to the sustainable development of the integrated formation of the agro-industrial complex as a whole.

References

1. Baibakova, T.V.: The sectoral approach to evaluating the efficiency of the integrated agrounities. Econ. Labor Manage. Agricult. **1**, 61–63 (2016a)
2. Baibakova, T.V.: Evaluating the efficiency of the integration processes in the agro-industrial complex. Econ. Manage. Problems Solut. **2**(8), 119–123 (2016b)
3. Karelina, M.G.: Comprehensive assessment of integration activity of business structures in Russian regions. Econ. Soc. Changes: Facts, Trends, Forecast **5**, 103–121 (2016)
4. Lo, K., Lys, T.Z.: The Ohlson model: contribution to valuation theory, limitations, and empirical applications. J. Acc. Auditing Finance, Summer **2000**, 48 (2000)
5. Rodionova, E. V. (2018). Integration processes in the meat products sub-complex of the agro-industrial complex of Russia: results, specifics, and ways of development. Economic and Social Changes; Facts, Trends, Forecast, **11**(2), 144–159.

6. Strelchov, B.E., Shiyanov, B.A., Burkovsky, V.L.: Modeling of the formation mechanism and evaluation of the efficiency of functioning of vertically integrated production structures. Newsletter VGTU **6**(1), 58–63 (2010)
7. Thematic Group on Sustainable Agriculture and Food Systems of the Sustainable Development Solutions Network.: Solutions for Sustainable Agriculture and Food Systems. Technical Report for the Post-2015 Development Agenda. New York, NY (2013).
8. United Nations. (2012). The Future We Want, Our Common Vision: Outcome document of the Rio+20 Conference. (A/CONF.216/L1). Retrieved from https://rio20.un.org/sites/rio20.un.org/files/a-conf.216l-1_english.pdf.

The Development of the Dairy Market in Russia

Galina N. Dudukalova, Alexander V. Tkach, and Alexander S. Nechitaylov

Abstract The article focuses on the importance of entrepreneurial activity of the Russian rural population for the development of the dairy market and dairy cattle industry, employing economic research methods. On the basis of the materials obtained as a result of the research, the economic and economic activities of various organizational and legal forms of management of the agro-industrial complex of the country in the production of commercial milk and dairy products are highlighted. More than that, the authors discuss the role, place, and volumes of supplies to the domestic dairy market. The paper also analyzes critical tendencies in the sphere of the development of domestic dairy cattle breeding in all forms of management in the village, taking into account the carried-out economic transformations in the country. The current situation in the system of commodity distribution channels and purchases of milk and dairy products for import from the CIS countries and foreign countries is considered. The trends and emerging prospects for the development of trade and procurement activities in the international market of milk and dairy products are analyzed. The forecast of expansion of the range of trade in milk and products of its processing is formulated. The reasons of prevalence of volumes of import over export of milk and dairy products are revealed. ways of improvement of development of the dairy market are offered. The authors provide proposals and recommendations to improve the efficiency of small business working in the domestic dairy cattle industry, as well as increase their importance in the supply of milk and dairy products to the domestic dairy market.

G. N. Dudukalova
Volgograd Cooperative Institute (Branch of the Russian University of Cooperation), Volgograd, Russia
e-mail: gdudukalova@rucoop.ru

A. V. Tkach (✉)
Department of Economics, Russian University of Cooperation, Mytishchi, Russia
e-mail: alex.tkach2017@yandex.ru

A. S. Nechitaylov
Attache of the Ministry of Foreign Affairs of the Russian Federation, Moscow, Russia
e-mail: anechitaylov@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_47

Keywords Entrepreneurship · Dairy market · Production and sale of milk · Import and export of dairy products · Dairy farms · Dairy enterprises

1 Introduction

Entrepreneurship in the functioning of the dairy market acts as an economic activity, accumulating the work of various specialized units whose main tasks include the production, processing, and promotion to the consumer of a wide range of milk and dairy products, which determines the content and filling of the dairy market. Entrepreneurship in the infrastructure of the dairy market is expressed in the specific forms of managing various spheres, sectors, and segments of the technological chain from the production to the marketing of products. Scientifically-based entrepreneurial activities contribute to the successful functioning and development of the dairy market. Entrepreneurship in the dairy industry contributes to a more economical expenditure of production potential, the identification of reserves, and the inclusion of previously unused resources in the production sector. The use by entrepreneurs of the achievements of scientific and technological progress in dairy cattle breeding ensures an increase in the productivity of cows, the safety of livestock, and the improvement of the quality of milk and dairy products.

2 Materials and Methods

The paper employs the methods of retrospective analysis, synthesis, and formalization of regulatory and structural changes that have occurred in the development of dairy farming in the country with the aim of assessing their impact on the production trends of milk and dairy products by various organizational and legal forms of management, determining the numerical composition of raw milk producers and their share in the total production of dairy products by type. It also analyzes the empirical data obtained in the process of obtaining statistical data on the development of dairy farming. The study took into account the provisions of legislative acts and state programs for the development of the dairy cattle industry, materials of Rosstat, and the observations of the authors.

3 Results

The analysis of the dairy cattle breeding industry's development in Russia revealed the consequences of economic reforms that had an impact on the development of the domestic dairy market. In farms of all categories, the number of cattle from 1992 to 2017 decreased from 52.2 to 18.7 million animals (64.2%). During this period, the number of cows decreased from 20.2 to 8.2 million animals (59.4%, more than half). The reduction in the number of dairy cows was accompanied by a decrease in milk production from 47.2 to 31.2 million tons (33.9%). At the same time, the supply of domestic dairy products to the market decreased. Thus, the sale of domestic-produced animal oil decreased from 388 to 340 thousand tons (12.4%). During the reviewed period, the annual milk yield per cow increased from 2243 to 5660 kg, or 2.5 times; the production and sale of cheese increased from 339 to 793 thousand tons, or 2.3 times [1]. The reduction in the number of cows was accompanied by a decrease in the supply of domestic dairy products to the dairy market. Many dairy farms were liquidated and devastated. Accompanied by the loss of jobs in the countryside and the migration of the rural population (former livestock workers) to the cities, many rural settlements disappeared from the map of Russia (Table 1).

There was a stagnation in the development of dairy cattle breeding, and only in 2017 was there a slight increase compared to the previous year by 0.3 million tons (1%). With a decrease in domestic production, the import of dairy products increased every year. From 1992 to 2010, it increased from 3.2 to 8.2 million tons or by 5.0 million tons, which is 2.6 times.

Since 2015, the volume of imports of milk and dairy products has decreased and in 2017 amounted to 6.6 million tons; however, that level is 2 times higher than the level in 1992. In general, taking into account Russia's own production and imports from 1992 to 2017, the volumes of milk resources and dairy products in Russia have decreased from 52.3 to 39.4 million tons (by 25%), so the dairy market began to supply dairy products by a quarter less. As a result, the population has reduced the consumption of dairy products in their diets. So, if in 1992, the volume of personal

Table 1 Dynamics of the development of dairy cattle breeding in farms of all categories of the Russian Federation

Years	Cattle in farms of all categories, million heads		Milk production on farms of all categories, million tons	Milk yield per cow (kg)	Sale, thousand tons	
	Total	Incl. cows			Animal oils	Cheeses
1992	52.2	20.2	47.2	2243	…	…
2000	27.5	12.7	32.3	2341	388	339
2005	21.6	9.5	31.1	3280	476	689
2010	20.0	8.8	31.8	4189	364	808
2015	19.0	8.4	30.8	5140	355	762
2016	18.8	8.3	30.8	5370	340	793
2017	18.7	8.2	31.2	5660	…	…
2017 in %. to 1992	35.8	40.6	66.1	252	…	…

Source Rosstat [2]

consumption of milk and dairy products amounted to 41.8 million tons, in 2017, it was only 34.2 million tons (18% less). The population's demand for milk and dairy products remains unsatisfied. The expenditures on dairy products for personal consumption after 2010 have reduced every year (Table 2).

The analysis of the dynamics of milk production for various categories of farms shows the role and place of each group in the formation of domestic resources of dairy products in the market. From 1992 to 2017, agricultural organizations reduced the production of raw milk from 32.2 to 15.7 million tons (51.2%). The reduction in milk production by agricultural organizations reached its bottom in 2010, with a decrease of 14.3 million tons, or lower than the 1992 level by 17.9 million tons (55.6%). Since 2015, there has been an increase in the production of raw milk by agricultural organizations. So, in 2017, its production increased compared to 2010 from 14.3 to 15.7 million tons (increase of 1.4 million tons, by 9.8%). The share of agricultural organizations in the total milk production in Russia from 1992 to 2017 decreased from 68.1 to 50.2% (by 17.9%). The second place in terms of milk production is occupied by households. Moreover, their share in the gross volume of raw milk produced in the country from 1992–2017 increased from 31.4 to 42.1% (10.7%). At the same time, it should be noted that the household production of raw milk over the years decreased from 14.8 to 13.1 million tons (11.5%). It must be emphasized that from 1992–2000, there was an increase in milk production. However, since 2010, there has been an annual decline in milk production in this category of farms from 16.0 to 13.1 million tons (18.1%). The main reasons for the decline in milk production in rural farmsteads are a reduction in the number of cows in households and a decrease in the rural population who want to keep dairy cows.

In the years under review, the number of cows in peasant (farmer) farms increased. The volumes of raw milk production and its supply to the dairy market increased. In this category of farms, from 1992–2017, the gross production of raw milk increased from 248 to 2391 million tons (21.4%). But the share of peasant (farmer) farms in the total volume of milk produced in the country is not large and amounted only to 7.7% in 2017. However, annual growth is noticeable both in milk production and in specific gravity in total production (Table 3).

The efficiency of entrepreneurs and the stable functioning of the links of the logistics system in the dairy market largely depend on the stability of milk prices. The analysis of the fluctuations in consumer prices for dairy products for 2000–2017 shows that consumer price indices for butter in Russia have experienced steady growth since 2000, increasing annually. Compared to the previous year, in 2010, the price of butter increased by 23.3%, and in 2016, it increased by 20.5%. A similar situation developed with rising prices for milk and dairy products.

In 2000, in relation to the previous year, prices for milk and dairy products increased by 21.1%, and in 2010, they increased by 16.7% over 2005. A similar situation has developed in the cheese market, wherein 2010 cheese prices also increased by 19.9% compared to the previous year.

The rapid increase in prices for milk and dairy products affects the purchasing power and demand of the population for products. Here, one of the determining factors is the imbalance between rising prices and the rising wages of the consumers

Table 2 The dynamics of resources and the use of milk and dairy products in Russia (million tons)

Indicators	Years							2017 in % to 1992
	1992	2000	2005	2010	2015	2016	2017	
Resources								
Stocks at the beginning of the year	1.9	1.3	1.7	1.9	2.1	1.9	1.7	89
In % to the previous year	100	68	130	111	110	90	89	x
Production	47.2	32.3	30.8	31.8	30.8	30.8	31.1	66
In % to the previous year	100	68	95	103	97	100	101	x
Import	3.2	4.7	7.1	8.2	7.9	7.5	6.6	206
In % to the previous year	100	146	151	115	96	94	88	x
Total resources	52.3	38.3	39.6	41.9	40.8	40.2	39.4	75
In % to the previous year	100	73	103	106	97	98	98	x
The usage								
Production consumption	7.8	5.2	4.1	4.3	3.3	3.2	2.9	37
In % to the previous year	100	66	79	105	76	97	90	x
Loses	0.04	0.03	0.02	0.03	0.03	0.03	0.03	75
In % to the previous year	100	75	66	150	100	100	100	x
Export	0.2	0.5	0.5	0.5	0.6	0.6	0.6	300
In % to the previous year	100	250	100	100	120	100	100	x
Personal consumption	41.8	31.3	33.2	35.2	34.9	34.7	34.2	82
In % to the previous year	100	75	106	106	99	99	98	x
End of year stocks	1.2	1.2	1.8	1.9	2.0	1.7	1.7	141
In % to the previous year	100	100	150	105	105	85	100	x

Source Rosstat [2]
x No data

Table 3 The trend of milk production in Russia by category of farms

Indicators	Years						2017 ± to 1992
	1992	2000	2010	2015	2016	2017	
Agricultural organizations							
Milk, mln. tons	32.2	15.3	14.3	14.7	15.1	15.7	48.8
Share in total production (%)	68.1	47.3	44.9	47.8	49.0	50.2	**−17.9**
Households							
Milk, mln. tons	14.8	16.4	16.0	14.1	13.5	13.1	88.5
Share in total production (%)	31.4	50.9	50.4	45.6	43.9	42.1	**10.7**
Peasant (farmer) households (Including individual entrepreneurs)							
Milk, mln. tons	248	568	1484	2035	2195	2391	2143
Share in total production (%)	0.5	1.8	4.7	6.6	7.1	7.7	7.2

Source Rosstat [2]
*Significant result

of this type of product. The prevailing trend of average consumer prices for dairy products shows that in the country, the price for 1 kg of butter increased from ₽ 69.12 to 528.83 from 2000 to 2017, or 7.6 times. The rate of price growth was so significant that, in some years, it exceeded the size of the prices of the previous year at times. Such important dairy products such as whole pasteurized milk with the fat content of 2.5–3.2% also grew in price. Here, from 2000 to 2017, the price for 1 L increased from ₽ 9.70 to 53.45 (5.5 times). At the same time, the prices for rennet hard and soft cheeses increased significantly. Thus, from 2000 to 2017, the prices of these products increased from ₽ 85.17 to 478.88 per 1 kg (3.45 times) (Table 4).

The rational correspondence of prices for dairy products and incomes of the population ensures the successful functioning of entrepreneurs of the entire logistics system in the dairy market.

The consideration of the ratio of consumer prices for dairy products with the price of beef is of particular interest. Thus, if in 1992, the price of 1 kg of butter was 1.86 times higher than the price of 1 kg of beef, in 2017, this ratio was 1.65 times. In 1992, the price of 1 kg of beef was equal to 10 kg of pasteurized drinking milk with a fat content of 2.5–3.2%. In 2017, the price gap between 1 kg of milk and beef decreased as milk prices increased at a higher rate than beef prices. The prices for dairy products rose annually in the country, as evidenced by the dynamics of price indices of milk producers (Table 5).

An important link in the logistics chain in the dairy market is tracking the import of products and their place and role in the domestic food supply [3–5]. Due to the lag in the domestic development of dairy cattle breeding and the inability to fully satisfy the population's demand for milk and dairy products, Russia has been forced

Table 4 The trend of consumer prices for dairy products in Russia

Years	Consumer price indices for dairy products in the Russian Federation (December to December of the previous year in %)			The dynamics of average consumer prices for dairy products, ₽ per kilogram		
	Butter	Milk and milk products	Cheese	Butter	Pasteurized drinking milk (2.5–3.2% fat per liter)	Hard and soft rennet cheeses
2000	104.1	121.1	113.6	69.12	9.70	85.17
2005	108.2	110.5	112.0	102.42	17.35	138.72
2010	123.3	116.7	119.9	239.55	31.99	263.20
2015	110.6	111.5	108.7	397.75	47.61	418.61
2016	120.5	109.5	109.9	477.13	51.44	461.71
2017	109.6	105.2	103.7	528.83	53.45	478.88
2017 ± to 2000	5.5	−16.3	−9.9	459.71	36.10	393.71
2017 in % to 2000	x	x	x	765%	551%	345%

Source Rosstat [2]
x No data

Table 5 The dynamics of the ratio of consumer prices for dairy products with the price of beef in Russia (at the end of the year; %)

Years	Beef (except boneless meat)	Butter	Pasteurized drinking milk (2.5–3.2% fat per liter)	The dynamics of milk producer price indices (December to December of the previous year; %)
1992	100	186	10	…
2000	100	131	18	114.0
2005	100	88	15	111.4
2010	100	121	16	134.7
2015	100	126	15	102.9
2016	100	151	16	112.0
2017	100	165	17	101.4
2017 ± to 2000	x	−21	7	…

Source Rosstat [2]
x No data

to import significant volumes of dairy products from the CIS member countries and non-CIS countries.

A study of the situation with the provision of the country's population with milk and dairy products shows that the import of butter and other dairy fats into Russia is carried out in large volumes [6, 7]. So, while in 2000, 70.8 thousand tons of butter and other milk fat was imported to Russia, in 2017, it was already 98.8 thousand tons (39% more). It should be noted that the growth in imports of butter and other dairy fats to Russia was observed rapidly from 2000 to 2014 when the import of these products into the country increased from 70.8 to 150.0 thousand tons (2.1 times).

However, since 2015, imports of butter and other dairy fats have decreased by 2017 to 98.8 thousand tons (by 34.4%), which indicates positive trends in the development of domestic dairy cattle breeding.

The main importers of butter and other dairy fats to Russia are the CIS countries, which accounted for 49.0 thousand tons of imported butter and other dairy fats (69.2%) in 2000, and non-CIS countries, which imported 21.8 thousand tons (30.8%). By 2017, imports of these types of products increased from CIS countries to 74.1 thousand tons (1.5 times), while the share of imports of butter and other dairy fats from non-CIS countries to Russia decreased from 30.8% to 25.0% (Table 6).

One of the main directions in the activities of the marketing service in the logistics infrastructure of the dairy market is monitoring competitors' prices for the products supplied for sale. In the domestic dairy market of Russia, from 2000 to 2017, the total import prices for 1 ton of butter and other dairy fats increased from $1,389 to $5,365 (almost 3.9 times).

It should be noted that in trade with the CIS countries, import prices for 1 ton of butter and other dairy fats increased from $1,360 to $5,436 (4 times), which is slightly higher compared to the total import prices for this type of product.

Table 6 The dynamics of import of butter and other dairy fats into the Russian Federation

Years	Total, thousand tons	Including from:		The share of imports from:	
		The CIS countries	The non-CIS countries	The CIS countries	The non-CIS countries
2000	70.8	49.0	21.8	69.2	30.8
2005	133.0	71.4	61.4	53.7	46.3
2010	134.0	55.9	78.5	41.7	58.3
2013	144.0	46.6	97.7	32.4	67.6
2014	150.0	65.6	84.8	43.7	56.3
2015	95.9	76.2	19.7	79.4	20.6
2016	105.0	81.0	23.8	77.1	22.9
2017	98.8	74.1	24.7	75.0	25.0
2017 in % to 2000	139	151	113	108.4	81.2

Source Rosstat [2]

It must be emphasized that over the compared years, the prices for these imported products from the non-CIS countries rose the least from $ 1,454 to $5,150 per 1 ton (3.5 times).

In 2000, import prices for 1 ton of butter and other dairy fats from the CIS countries were lower than the total import prices by $29, while the prices of these types of products from the non-CIS countries exceeded the total import prices by $65.

At that time, it was more profitable for Russia to buy butter and other dairy fats in the CIS countries, having a profit of $94 per ton of purchased products, than in the non-CIS countries. However, by 2017, the situation of import prices for dairy products has changed. The prices for 1 ton of butter and other dairy fats in the CIS countries rose to $5,436, while the import prices for these types of products from the non-CIS countries amounted to $5,150, or $286 less.

General import prices for butter and other dairy fats in Russia from 2000 to 2017 did not change evenly. However, the general trend of their growth continued, with the exception of 2015. This also applies to the prices in trade with the CIS countries and the non-CIS countries. The prices increased sharply in 2010 compared to 2005 (more than 2 times), as well as in 2017 compared to the previous year by 41% (Table 7).

Table 7 The dynamics of average import prices for butter and other dairy fats in the Russian Federation (US $ per ton)

Years	Import prices in Russia						± to the total import prices of other countries:	
	General		Including in trade with the countries					
	Total	In % to the previous year	CIS	In % to the previous year	Non-CIS	In % to the previous year	CIS	Non-CIS
2000	1389	100	1360	100	1454	100	−29	65
2005	1845	133	1806	133	1891	130	−39	46
2010	3751	203	4410	244	3282	173	659	−469
2013	4835	129	5353	121	4587	140	518	−248
2014	4936	102	4955	92	4920	107	89	−16
2015	3245	66	3156	64	3586	73	−89	341
2016	3815	124	3862	122	3654	102	47	−161
2017	5365	141	5436	141	5150	141	71	−71
2017% 2000	386	x	400	x	354	x	x	x
2017 + / to 2000	3976	x	4077	x	3696	x	100	−6

Source Rosstat [2]
x No data

4 Discussion

The successful functioning of the dairy market depends on the reliability of sales channels, promotion of dairy products from the manufacturer to the consumer. One of the most important stages of the logistics chain of the dairy market infrastructure is the link of dairy farms and dairy complexes, households, peasant (farmer) farms, and individual entrepreneurs engaged in the production of milk—raw materials and dairy products. The success of the dairy market is determined by the effective logistics, in which the primary elements are the production of dairy products, marketing, and advertising service. In the infrastructure of the dairy market, there are entrepreneurs, procurement (collecting raw milk and supplying it to wholesalers), milk transporters, and milk processing enterprises that produce dairy products in a wide range, a retail network that brings dairy products to the mass consumer. The synchronicity of the dairy market is influenced by the quality and reliability of information and financial flows and the rhythm of the participants' work, each of which performs its functions, the quality of which affects the stability of the entire dairy market system [8].

5 Conclusion

The conducted research of the state, functioning, and trends of the country's dairy market revealed the consequences of economic reforms and transformations that took place in the modern history of Russia, which had a significant impact on the development of domestic dairy cattle breeding as the main production part of the logistics chain in the infrastructure of the milk market and products of its processing. In connection with economic transformations in the agrarian sphere of the country, the role of peasant (farmer) farms in milk production (including individual entrepreneurs who purchased cattle, cows, formed the main dairy herd, mastered technologies, and increased milk production for commodity purposes) has significantly increased. The main vectors for successful development of the domestic dairy market are as follows: developing dairy cattle breeding; increasing the productivity of cows; improving ecological purity of raw milk materials and dairy products; introducing highly efficient technologies (including through the construction of new dairy farms with modern milking equipment); developing a transport network for deliveries of milk-raw materials as on processing plants and retail network. The stability of the domestic dairy market and the expansion of the range of supplies of dairy products is affected by the growth of milk production, which depends on the organization of the dairy cattle industry and the timely replenishment of the dairy herd with highly productive cows, thereby increasing the profitability of producers and improving their financial management results.

Acknowledgments The work was supported by RFBR grant, project No. 17–02-00182 "Institutional Model Innovative Development of Consumer Cooperation System."

References

1. Avarsky, N.: Theory and practice of development of infrastructure of commodity movement of milk and dairy products (foreign and domestic practice). Encyclopedia of Russian villages, Moscow, Russia (2013)
2. Rosstat: Russia in numbers—2018: brief statistics. Rosstat, Moscow, Russia (2018)
3. Battalova, A.: Food security as a component of economic security system of Russia. Procedia Econ. Finan **27**, 235–239 (2015)
4. Bazgă, B.: Food security component of sustainable development—prospects and challenges in the next decade. Procedia Econ. Fin. **32**, 1075–1082 (2015)
5. Bogoviz, A.V., Semenova, E.I., Sandu, I.S.: Innovational tools of provision of food security through state support for the AIC in the conditions of the digital economy. Lecture Notes in Networks and Systems **57**, 334–340 (2019)
6. Nechitaylov, A. S.: Development of the market of ecologically safe milk and dairy products. Publishing and trading Corporation “Dashkov and Co.”, Moscow, Russia (2017).
7. Paptsov A. G.: The directions of global food security. AIC Econ. Manage. **10**, 103–107 (2015)
8. McNeil, A.O., Kerr, W.A.: Vertical coordination in a post-command agricultural system—can Russian dairy farms be transformed? Agric. Syst. **53**(2–3), 253–268 (1997)

Improving the Management System of the Agricultural and Industrial Complex

Sergey V. Kulaykin and Andrey K. Markov

Abstract The paper focuses on the issues of improving the management of the agro-industrial complex, which is a condition for increasing the efficiency of its industrial and financial activities. Our research shows that the processes of economic development, including in the agricultural sector, are determined by the quality of the management system. Regional agribusiness is one of the main elements of the entire agribusiness management system, which essence is to establish the optimal ratios of individual blocks, modules of the production vertical, and structural horizontal. The functioning of these regional agribusiness management units is based on a rational combination of integration and cooperation in the agricultural sector, integrated information systems, price and financial-credit mechanisms, budget support and investments. In the proposed model for managing regional agribusinesses on the principles of state regulation, the priority role belongs to state bodies, which allows us to establish intersectoral and interregional ties in contemporary conditions.

Keywords Agro-industrial complex · Economy · Management system · Efficiency

1 Introduction

In Russia, a balanced and well-thought-out strategy for socio-economic development made it possible to avoid the economic disasters of the global economic crisis, maintain economic stability, and continue targeted activities to improve the people's quality of life and standard of living [8].

However, the current global economic and geopolitical processes pose new challenges and require an adequate and timely response.

S. V. Kulaykin (✉)
Federal Research Center for Agricultural Economics and Social Development of Rural Areas, All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: kay1958@yandex.ru

A. K. Markov
Russian Academy of Personnel Support of Agro-Industrial Complex, Moscow, Russia
e-mail: aan@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_48

This is due to both trends in globalization and the international division of labor, and the state of the agricultural sector of Russia.

Food security is the most vulnerable area of the Russian economy in social and technological terms since food security reflects an urgent daily need of the entire population.

The priority national project and the State program had a positive impact on the development of agriculture, but for the further development of agri-food policy, accounting for the trends and prospects of agricultural production, it is necessary to adjust strategic priorities and increase the efficiency of agricultural management institutions, which should contribute to agricultural innovation, increase food security without imports, and reduce technological and commodity dependence on other countries.

For the further development of agri-food policy, taking into account the trends and prospects of agricultural production, it is necessary to increase the efficiency of institutions and management mechanisms, state support, and regulation of the agricultural sector, which should contribute to the innovative development of agriculture, increase the country's food supply of its own production, and reduce technological and commodity dependence on foreign countries.

2 Materials and Methods

Databases of the Federal Service for Statistics, the Ministry of Agriculture of Russia, the results of opinion polls, and personal observations of the authors were used in the course of the study as information sources.

The methodological and theoretical basis of the study is the work of domestic and foreign scientists who have studied the issues of improving the agricultural management system. In order to complete the study, methods such as applied abstract-logical, analytical, expert research, and sociological research methods were applied.

3 Results

AIC is a multi-level, multi-link, diversified, multi-directional economic system. From a functional, economic point of view, there can be distinguished macro-, meso-, and microeconomic levels of the agro-industrial complex. The macro level reflects the ongoing processes of a landslide decline in the agro-industrial complex and, in recent times, the individual rudiments of its revival.

The mesoscale of the functioning of the agricultural sector involves interaction across industries and regions.

The micro-level reflects the functioning of economic entities: agricultural enterprises, private household plots, farms, and market agents.

There are powerful multidirectional ascending and descending bonds between the functional levels (macro-, meso-, and micro-). The management of the agro-industrial complex as a whole and of its economic bloc cannot be imagined without the interconnection of the above levels.

This interrelation is especially pronounced during the periods of social transformations, when the agro-industrial complex economy transitions from the stable to impulse mode, and one can trace how the changes at one of these levels affect the functioning of another level. Thus, the destruction of the wage system at the macro-level led to the forced development of private household plots and the transition of the majority of the rural population to self-sufficiency (to the micro-level).

A distinctive feature of the agro-industrial complex as an economic system is its social orientation. When considering the functioning of the agro-industrial complex in the institutional aspect, such institutions as hierarchy, integration, cooperation, etc. should be taken into account. Therefore, the destruction or change of even one institution affects the entire economic structure of the agro-industrial complex. Given the exposure of the agro-industrial complex to the influence of external factors, it requires focused, coordinated work at all levels of management and the consolidation of norms and rules. In this regard, the role of the state in ensuring inter-level, inter-industry, and inter-regional relations should be strengthened.

However, the role of the state in determining the social rules of relations at the macro level is still weakly manifested [2].

In each specific period, the key role among the factors of economic dynamics belongs, as a rule, to one of the levels. This level is currently microeconomic, i.e., the functioning of the subjects of the agri-food market in the form of enterprises and other institutions.

However, the liberal development path of the agricultural sector led to significant losses in agriculture (the economic and institutional ties of agricultural enterprises with other organizations and market entities were destroyed) [1]. In these conditions, the competition between them is not in the commodity market, the field of improving product quality, or reducing costs but in the attempts for attracting funds, primarily budget subventions, grants, and subsidies at the municipal, regional, and federal levels.

Currently, the agricultural sector is experiencing economic difficulties. Despite some stabilization of agricultural production (grain and dairy sub-complexes), crisis phenomena have not been overcome yet [7]. In agriculture, three priorities should be distinguished:

- increasing the financial stability of agricultural enterprises;
- ensuring food security (implementation of the import substitution program and ensuring rational norms of food consumption that meet modern requirements of healthy nutrition);
- creating favorable economic climate in agriculture.

The organizational and economic mechanisms of regional agribusiness management are one of the main elements of the entire agribusiness management system, which, in essence, seeks to establish the optimal ratios of individual blocks and modules of the vertical production and horizontal structure.

The functioning of these units of regional agribusiness management is based on a rational combination of integration and cooperation in the agricultural sector, integrated information systems, price, and financial-credit mechanisms, budget support, and investments. In the proposed model for managing regional agribusiness, based on the principles of state regulation, the priority role belongs to the state bodies, which allow us to establish intersectoral and interregional ties in modern conditions.

When considering issues of state support, specific features of agricultural production should be taken into account: mechanisms, factors, and conditions. The need to take these features into account should lead to the conclusion that the successful operation of integrated formations is largely determined by the existing relations of agricultural enterprises with the leading municipal and regional authorities. Without such contacts, agricultural producers and food industry enterprises are unlikely to find integration partners, as commercial banks are extremely reluctant to go into agribusiness without the support and guarantees of the state.

4 Discussion

The organizational and economic mechanism for managing a regional agro-industrial complex requires a systematic approach to resolving issues of targeted programs involving both centralized budgetary funds and private financial sources in the agro-industrial complex [6]. In this case, the optimal form of agricultural management at the regional level is the mixed management scheme, which provides the improvement of the economic mechanism, intraeconomic and intrasectoral economic relations. Its goal is to create an economic environment that ensures the efficient operation of all sectors and enterprises of the agro-industrial complex, regardless of the form of ownership [4]. The formation of effective management models is of particular importance in increasing the competitiveness of agricultural enterprises. In this management scheme, the determining forms are inter-farm cooperation and agro-industrial integration, which should be supported by both regional and municipal governments. Integrated formations should develop in the direction of improving product chains according to the scheme: production—processing—sale of agricultural products.

In the formation of organizational and production structures at the district level, it is advisable to create, on the basis of the regional department of agriculture, an association of agricultural, industrial, commercial enterprises, regional business support centers, consumer cooperation organizations, and credit cooperatives [3, 5].

The work plan of these associations should include management of all subjects of the agricultural market of the region, which, first of all, would include the following:

- the development of promising integration schemes for agricultural enterprises of the district;
- the identification of channels for possible investment and budget support;

- the formation of a mechanism of economic relations between enterprises of the agro-industrial complex of the region, including within the framework of integration ties;
- the formation of a database of information resources and the legal field.

5 Conclusion

Based on the foregoing, it is legitimate to conclude that the development of the system of state and municipal management of the agro-industrial complex should be accompanied by a transition to progressive management models at the levels of the administrative hierarchy: federal, district, regional, and municipal.

Summarizing the foregoing, we propose the following algorithm for modeling management systems:

1. the formation of the objective function, based on the new management paradigm, which consists in ensuring the food security of the country and regions and priority ensuring favorable conditions for production and living in rural areas;
2. the creation of an optimal agribusiness management structure, providing the presence of both traditional market structures and those providing strategic management and innovative development of agribusiness;
3. the formation of the institutional framework and legal basis, as well as the development of an improved management mechanism and communication system (administrative, financial, and other interactions of the subject and the management object, taking into account a set of factors);
4. practical implementation, development, and further improvement of the development model of the agricultural management system.

It is completely obvious that when preparing progressive agricultural management models, the developers must take into account the following factors: natural-climatic; economic; the specifics of the development of the region (country, federal district, constituent entity of the Russian Federation, or municipal formation); management level; security of labor resources and their quality characteristics; readiness of subjects and control objects to perceive this model; and financial, logistical, and other opportunities, etc.

References

1. Gokhberg, L.: The national innovation system of Russia in the context of the "new economy." Econ. Issues **3**, 26–38 (2013)
2. Makovetsky, V., Priemko, V.: Monitoring of information support for agricultural producers. AIC: Econ. Manag. **1**, 71–75 (2011)
3. Minakov, I.A.: Economics of Agribusiness Sectors. KolosS, Moscow, Russia (2015)

4. Mukhamedzhanov, E.R.: Consulting support for the innovative development of the agro-industrial complex of Russia. Oil Gas Bus. **1**, 66–68 (2011)
5. Muromtsev, C.B., Stashevskaya, I.A.: Strategic Management of Agribusiness. Krasnodar Regional Institute of Agribusiness, Krasnodar, Russia (2018)
6. Nechaev, V., Polutina, T., Zemlyanykh, E.: Scientific information cluster in the AIC of the Krasnodar territory. AIC: Econ. Manag. **10**, 23–29 (2010)
7. Rabinovich, L.M.: The Regulatory Framework for Economic Incentives. Rosagropromizdat, Moscow, Russia (2018)
8. Verenikin, A.O., Voloshin, D.I.: Economic growth and the vector of development of modern Russia. Bull. Moscow Univ. (Econ.) **2**, 86–99 (2014)

Diversification as a Factor of Strategic Development of Agricultural Production

Sergey V. Kulaykin and Andrey K. Markov

Abstract The agro-industrial complex of Russia is one of the most important sectors of the national economy. For most agricultural enterprises, the current situation once again actualizes the need to optimize and improve agricultural production, expanding its range based on the needs of processing enterprises and the market conditions for agricultural raw materials and food. Business entities need to build long-term plans that would ensure sustainable development. However, enterprises must look for the alternatives to the existing specialization of production. In this regard, there is a need for a strategic approach to the management of agricultural enterprises. The enterprises are faced with the task of finding development strategies that could solve a number of economic problems in agriculture and rural development. One of the strategic alternatives to long-term planning is diversification. The paper focuses on the theoretical issues of diversification in the agro-industrial complex. It also suggests the levels of diversification (macro-, meso-, micro-); its types, depending on the field of application (financial, industrial); its focus (industry, intra-industry); as well as further directions of diversification in the agro-industrial complex.

Keywords Diversification · Agro-industrial complex · Market structure · Production indices

1 Introduction

The agricultural sector is one of the important components of the national economy. It performs a number of socially significant functions, such as ensuring food security. The labor resource function also depends on it, since it is the agricultural sector

S. V. Kulaykin (✉)
Federal Research Center for Agricultural Economics and Social Development of Rural Areas—All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: kay1958@yandex.ru

A. K. Markov
Russian Academy of Personnel Support of Agro-Industrial Complex, Moscow, Russia
e-mail: aan@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_49

that employs the majority of the rural population, and in some cases, the population of small towns [2]. In addition, the agrarian sector is closely connected with other sectors of the national economy and supplies them with primary raw materials.

In the context of a constantly changing market structure caused by the active introduction of new advanced and innovative technologies, the corresponding structural changes are also taking place in the agricultural sector. So, the proportion is gradually reduced and, accordingly, the role of some sectors (in particular, agriculture) is weakening. The structure of rural employment and rural population's source of income are also changing.

Currently, the basis of the agricultural sector of the Russian economy is agriculture. The share of agriculture in gross value added (GVA) is still significant. Compared to 2010, in 2017, it increased by 0.8%, which may indicate the extensive nature of growth in the agrarian sector of the Russian economy.

It is necessary to increase not only the quantitative indicators of production volumes in agriculture but also to switch to the production of products with high added value and better quality, which may result in the increase of the industry margin. It is necessary to develop a niche for organic products.

Currently, Russia is interested in a diversified model of rural development [5, 8]. According to the concept of sustainable development of rural territories, the diversification of the rural economy is one of the main directions of increasing the sustainability of rural development [1, 4].

2 Materials and Methods

The concept of diversification is multifaceted and widely applicable to various sectors and types of economic activity. Currently, there are a number of methodological approaches for determining diversification and its distinctive features in relation to the agricultural sector of the economy [6, 9].

A number of foreign researchers are focusing on considering the problem of diversification as a survival strategy at the level of individual economic entities (households of the population living in rural areas) by expanding the diversity of farm activities [3, 7, 10].

The issues of diversification of agricultural sector are also reflected in the following state programs: *The Concept of Sustainable Development of Rural Areas for the Period until 2020* and *The Strategy for Sustainable Development of Rural Areas for the Period until 2030*, as well as in the programs and reporting documents of *the OECD Rural Development Departments*, the *UK Department of the Environment, Food and Agriculture*, and *European Research Service*.

3 Results

Significant issues of diversification of the Russian economy's agricultural sector include the high concentration of production in agricultural organizations (agricultural holdings), which produce more than half of the total volume of certain types of products, thereby hampering the development of small and medium-sized businesses and monopolizing the market. Also, there is a problem of imbalance in certain types of products in the Russian agricultural sector.

When considering various conceptual approaches to the definition of diversification, it is necessary to distinguish several levels of diversification (macro-, meso-, micro-), its types depending on the scope (financial, industrial) and on the direction (industry, intra-industry).

The analysis of the research literature also allowed us to conclude that, in most sources, diversification is understood primarily as an expansion of diversity in various directions depending on the field of application. In this regard, we believe that such types of diversification can be distinguished: financial, industrial, and industry and intra-industry.

We have supplemented the concept of diversification in relation to the agricultural sector, which is proposed to be understood not only as the development of non-agricultural activities but also as the expansion of various sectors in agriculture, as well as the expansion of relationships between sectors. This allowed the authors to highlight certain elements of diversification in the agricultural sector of the economy (i.e., levels, types, forms, strategies, and directions).

The main forms of diversification in the agricultural sector, in our opinion, include integration and specialization. Moreover, integration involves the expansion of activities through penetration into new industries that are not related to the core business of the enterprise. Specialization, on the contrary, is based on deepening diversification within the framework of the core business. Depending on the nature of the relationship between sectors, two diversification strategies can be distinguished (a related type and an unrelated type).

Let us single out two areas of diversification in the agricultural sector—the development of agricultural activities and the development of non-agricultural activities. The development of agricultural activities is associated with the expansion of the diversity of types of products in the crop and livestock sectors, both in its traditional types and new types of products that are in great demand and bring more income. The development of non-agricultural activities is associated with the development of agricultural processing; timber processing and logging; manufacturing industries; various types of services in addition to agricultural production; and the development of various types of tourism in rural areas, including agricultural tourism, etc.

The conducted analysis of the state of the agrarian sector made it possible to single out certain main changes that have occurred there recently. In connection with the active policy of import substitution and the growing interest on the part of the state in the development of domestic production, since 2011, in agriculture, there has been a steady increase in the main production indices in the crop and livestock sectors. Compared to 2010, in 2017, the share of agriculture in the GVA increased by 0.8%. The cultivated areas are growing mainly for the types of crops for which production is more economically efficient (export-oriented, in high domestic and foreign demand) as well as those crops that can be used to produce various types of products, not just agricultural ones. Thus, when compared to 2000, in 2017 the cultivated areas of the following crops increased 19.4% for wheat, 262.8% for corn, 18.6% for rice, 90.5% for legumes, 429.3% for soybeans, 221% for rapeseed, 63.6% for sunflowers, and 37.6% for sugar beets. Compared to 2010, in 2017, the sown areas of corn increased the most by 104.5%, soybeans by 84.8%, legumes by 34.3%, and rapeseed by 14.3%. However, the sown area of crops such as rye, oats, millet, spinning, and forage crops has been significantly reduced. Compared to 2000, in 2017, the cultivated areas of rye decreased by 64.3%, oats by 36.7%, buckwheat by 23.6%, millet by 72.6%, linen-flax by 55.1%, forage crops by 43.3%, and potatoes by 27.6%. In relation to 2010, in 2017, the sown areas of rye decreased the most by 28.6%, millet by 16.4%, forage crops by 9.7%, potatoes by 7.2%, and linen-flax by 5.3%.

Currently, the problem of the food self-sufficiency has been resolved in almost all main types of livestock products.

In 2017, compared with 2010, the number of pigs increased by 27.9%, sheep and goats by 13.8%. However, the number of cattle runoffs continues to decline, compared to 2010. In 2017, this indicator decreased by 6% (including cows by 5.7%) and over the past year by 1.1%. Over the past year, the number of sheep and goats has also slightly decreased by 0.4%. The number of poultry in farms of all categories in 2017 compared to 2000 increased by 62.2%, compared to 2010 by 23.2%, over the past year by 1%.

In general, from 2010–2017, there was a steady tendency towards an increase in the production of livestock and poultry for slaughter in farms of all categories. In terms of farm categories, this indicator grew most in agricultural organizations, increasing in 2017 by 5.8% compared to 2016, and by 66.2% compared to 2010. In peasant (farm) enterprises, the production of livestock and poultry for slaughter in live weight also increased in 2017 compared to 2016 by 2.7%, and by 38% compared to 2010. However, in 2017, on the contrary, the production in households decreased by 3% compared to 2016, and by almost 20% compared to 2010.

However, the production of cattle meat still has problems. In 2017, it decreased by 1.6% compared to 2016, and by 7.3% compared to 2010. At the same time, in agricultural organizations in 2017, the production of these products increased by 2% in relation to 2015, but in relation to 2010 decreased by 6.6%. In peasant (farm) enterprises, the value of this indicator increased in 2016 by 4.3% compared to 2015 and by 63.3% compared to 2010. In households, the production of cattle meat decreased by 4.2% compared to 2015 and by 13.1% compared to 2010.

Let us note that one of the most significant problems in animal husbandry is the development of dairy farming. In 2017, milk production in farms of all categories practically remained at the level of 2016, and the value of the indicator decreased by 0.02%.

There is a transformation in the structure of rural employment in the direction of decreasing the level of agrarianization of residents, which is reflected in a decrease in the share of people employed in the primary sector of the economy (agriculture, hunting, and forestry). At the same time, the share of people employed in the secondary and tertiary sectors of the economy (primarily economic activities such as industry, construction, and services) are, on the contrary, increasing. The average annual number of people employed in agriculture, hunting, and forestry in 2017 amounted to 6.2 million people (9.2% of the total number of people employed in the economy). Between 2005 and 2017, the average annual number of employees in the above sectors decreased by 1.3 million people or from 11.2% of the average annual number of employees in the economy to 9.2%, which is a 2% decrease. In 2005, according to the sample labor force survey, 10.1% of the population was employed in agriculture, hunting, and forestry; in 2010, 7.7%; and in 2017, 6.7%. Thus, from 2005 to 2017, the value of this indicator decreased by 3.4%.

It should be noted that the employment structure of the rural working population is also changing in the direction of increasing the number of people employed in non-agricultural economic activities (industrial production, construction, transport, and communications, as well as in trade and services). According to a sample survey of the population in 2000, 49.3% of the rural population was employed in agriculture, hunting, and forestry, in 2007—31.8%, and in 2017—22.6%. Thus, from 2000 to 2017, the share of employees in these types of activities decreased by more than 2 times. The share of the rural population employed in industrial production in 2000 was 9.5%, in 2007—12.7%, and in 2017—14.1%. In general, from 2000 to 2017, it increased by 4.6%. The share of the rural population employed in construction increased more than 3 times. In 2000, it amounted to 2.4%, in 2007—5.3%, in 2017—7.7%. The share of the rural population employed in the field of trade and the provision of services increased significantly from 6.9% in 2000 to 14.4% in 2017.

4 Discussion

The analysis of the research literature showed that, at the moment, in scientific works, there is no definition of the factors of economic diversification. At the same time, much attention is paid to the concept of growth factors or drivers, which is often found in studies internationally.

The authors offer their own definition of the factors of diversification of the agricultural sector, which should be understood as the conditions that contribute to the diversity of agricultural activities in the economy and enable closer interaction between agriculture and the non-agricultural sectors of the economy. When typologizing the factors of diversification of the agricultural sector, different criteria can be used. Thus, according to their significance, primary and secondary factors are distinguished. For the criterion of the method of production expansion, factors are extensive or intensive.

Depending on the sphere, the factors are economic, socio-demographic, political, and institutional. Depending on the specific features of industries and economic activities related to the agricultural sector of the economy, such factors are natural resources, production, and innovation.

The influence of certain factors on the diversification of the agricultural sector in Russia may be manifested to a greater or lesser extent. In our opinion, the following factors have the most significant impact on the diversification of the agri-sector of the Russian economy: natural and climatic features, development of the material and technical base (production capacity), regional specialization, investment, as well as the location of rural areas.

We assessed the degree of diversification on the basis of the employment structure of the rural population by types of economic activity in the main work with the use of index methods, namely Herfindahl indices, as well as the entropy index. Based on the calculations, we found that the employment structure of the rural population in 2017 became more diversified. The results of the Herfindahl index value for 2008 and 2017 are 0.143518 and 0.111695, respectively, and the entropy index is 2.187989 and 2.321315.

Lower values of the Herfindahl index show a lower concentration and, consequently, greater diversification. Respectively, the obtained index values for 2008 and 2017 indicate that the rural employment structure in 2017 has become more diversified.

On the contrary, higher values of the entropy index, in contrast to the Herfindahl index, indicate greater diversification. Since the value of the index in 2017 increased compared to 2008, this also confirms our assumption about the increased degree of diversification of rural employment.

An increase in the degree of diversification of rural employment may indicate an increase in the degree of diversification in the agricultural sector.

5 Conclusion

The choice of strategy for diversification of agricultural enterprises is determined by the internal potential and the potential of the external economic environment. The organizational and economic mechanism for choosing a strategy for diversifying the activities of an agricultural enterprise includes diagnosing and structuring its internal and external problems, formulating its mission and goals, strategic analysis, identifying strategic alternatives, choosing a strategy, monitoring its implementation, and evaluating its effectiveness.

References

1. Bogoviz, A.V., Semenova, E.I., Ragulina, J.V.: Agricultural products' quality. In: Lecture Notes in Networks and Systems, vol. 57, pp.154–160 (2019)
2. Bondarenko, L.V.: Rural employment and rural diversification. Agric. Econ. Russia **1**, 71–76 (2011)
3. Ellis, F.: Household strategies and rural livelihood diversification. J. Dev. Stud. **1**, 1–38 (2018)
4. Korbut, L.S.: The development of small non-agricultural business in the countryside. Nikon Read. **12**, 467–469 (2007)
5. Kundius, V.A., Pantyukhina, S.V.: Rural territories—alternative types of employment. AIC: Econ. Manag. **4**, 68–75 (2016)
6. Novitsky, E.: Problems of Strategic Management of Diversified Corporations. Bukvitsa, Moscow, Russia (2017)
7. OECD: (2015) New Rural Policy: Linking up for Growth. Memphis, TN
8. Orlova, O.A.: Diversification of enterprises: the nature and classification of species. Reg. Econ. Theory Prac. **8**(65), 9–11 (2008)
9. Rudyk, N.B.: Conglomerative Mergers and Acquisitions. Delo, Moscow, Russia (2015)
10. Siegel, P.B., Johnson, T.J., Alwang, J.: Regional economic diversity and diversification. Growth Change **26**, 261–284 (2015)

The Formation of the Optimal Sectoral Structure in the Agriculture of the Non-black Soil Regions of Russia

Boris A. Pozdnyakov and Irina V. Velikanova

Abstract In agriculture of the nonblack soil regions of the country, there are significant imbalances between the area of arable land and the insignificant scale of production in the industries where these lands are used, which is associated with a shortage of labor, material, technical, and financial resources. These facts lead to the inefficient use of arable land and their withdrawal from circulation. The study aims at justifying rational directions for improving the sectoral structure of agriculture in the non-black soil regions of the country, taking into account the need to stop the process of eliminating arable lands (the most valuable part of agricultural land) from circulation. The novelty of the study lies in the fact that the need for the formation of a more optimal sectoral structure in agriculture is proved not only for increasing the economic efficiency of production, but also for minimizing environmental losses associated with an inefficient use of agricultural land and their degradation. As a result of the study, it is established that the main direction of improvement of branch structure of agriculture in the nonblack soil regions in the conditions of a relative surplus of land resources is the development of dairy-meat cattle breeding and flax growing. An urgent measure aimed at stopping the degradation of arable lands is the return to crop rotation of perennial grasses. In order to provide the newly created specialized enterprises of the flax subcomplex with the possibility of placing flax crops on the unused or inefficiently used areas of arable land with highly fertile soils, it is necessary to solve the legal issues of their temporary withdrawal from inefficient owners.

Keywords Non-black soil zone · Agriculture · Industry structure · Arable land degradation · Environmental losses · Priority sectors

B. A. Pozdnyakov · I. V. Velikanova (✉)
FSBRI Federal Research Center for Bast Fiber Crops, Tver, Russia
e-mail: ivvelikanova@mail.ru

B. A. Pozdnyakov
e-mail: Vniilml1@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_50

1 Introduction

One of the ways to improve the production systems in agriculture is to optimize its industrial structure. The composition of industries is determined, firstly, by the presence of favorable environmental conditions for their functioning, and by the demand for the corresponding types of agricultural products.

The next important vector for optimizing the sectoral structure of agricultural enterprises and associations is ensuring its compliance with the composition and volume of available production resources (land, labor, material, technical, and financial), in order to achieve the highest possible economic results. Here, a counter process is also needed to be aimed at the formation of a rational structure of the resource potential.

In recent years, during the formation of the sectoral structure in agriculture of the non-black soil regions, there was also an urgent need to take into account the environmental consequences of the production activities associated with the inefficient use of agricultural land and, consequently, their degradation.

The purpose of the study is to justify rational directions for improving the sectoral structure of agriculture in the non-black soil regions of the country, taking into account the need to stop the process of eliminating arable land (the most valuable part of agricultural land) from circulation.

2 Materials and Methods

The study was carried out on statistical materials and reporting data of agricultural enterprises of the Tver region, the agrarian problems of which are typical for most nonblack soil regions of the European part of Russia.

The study used such methods of economic research as a system, computational, constructive, abstract logical, and historical analysis.

3 Results

In 1992, according to state land records in the Tver region, there were 1309 thousand hectares of arable land. Crops occupied 95% of the area of arable land. That is, if we keep in mind the presence of clean vapors, arable land was fully utilized. However, by 2005, the area under crops was halved in comparison with 1992. It continued to decline in subsequent years, albeit at a slower pace. From the analysis of the data in Table 1, we can conclude that approximately half of the arable land has not been used for more than 15 years. During this period, in the nonblack soil areas, the abandoned agricultural land, as a rule, is overgrown with shrubs and light forests.

Table 1 The use of arable land in the Tver region

Indicators	Years				
	1992	1995	2000	2005	2017
Arable land occupied by crops, thousand ha	1241	1065	766	608	538
in % to 1992	100	85.8	61.7	49	43.3
Including the area of perennial grasses, thousand ha	457	533	527	448	402
The area of cereals, flax, potatoes, and other crops, which cultivation requires tillage, thousand ha	784	532	238	160	136
in % to 1992	100	67.9	30.4	20.4	17.3
The average annual number of cattle, thousands	512	356	214	144	86
The area of perennial herbs for a conv. animal, ha	0.9	1.5	2.5	3.1	4.6

Source The Consolidated annual reports of agricultural enterprises of the Tver region and Rosstat data

Currently, ¾ of the arable land is under crops of perennial grasses, and the remaining area contains field crops, which cultivation involves tillage. This situation would be quite acceptable if perennial grasses were not removed from crop rotations, periodically plowed to accommodate other crops and updated by sowing under cover of grain or without cover.

Nevertheless, the problem is that the soil is processed mainly in the same areas, and the areas of perennial grasses, listed under crops, are also at risk of hardening. The above refers to the areas where feed is not harvested, and the grass is not mowed.

To date, determining the area of arable land that is suitable for processing and does not require reclamation is possible only based on an inventory. However, the analysis of the perennial grasses productivity indicators gives us an excellent reason to assert that the arable land occupied by them is also subject to degradation. In 1992, the productivity of perennial grasses calculated according to the annual reports of agricultural enterprises amounted to 11.8% of feed units (f.u.) per 1 ha. These numbers are slightly lower than the average for the 1980s but can be considered as a completely reliable indicator. In 2017, the productivity of perennial grasses decreased almost four times and amounted to 3.1 f.u./ha, that is, it fell below the productivity of natural hayfields.

Fodder is harvested only on the part of the area of perennial grasses (in our estimation, 30–40%). In the rest of the area (partially used for grazing), there is a danger of shrub overgrowth.

In order to increase productivity, it is necessary to include perennial grasses in crop rotation, to carry out their periodic plowing for other crops and to update the stem.

However, the paradox of the current situation is that the existing number of cattle, which has decreased six times compared with 1992, is provided with sufficient fodder even with such low productivity of perennial grasses.

The area of perennial herbs per one conditional cattle increased up to 4.6 ha by 2017. It is more than two times higher than necessary to provide livestock with a feed even at a low level of crop production (Table 1).

The area of perennial grasses in 1992 and the 1980s was about one hectare per one conditional cattle. It did not ensure the production of a sufficient amount of feed and limited the annual productivity of the dairy herd to 20 centners of milk. Currently, cow productivity exceeds 40 centners. That is, under current technological conditions in dairy and meat cattle breeding, enough fodder is produced.

The main direction of improving the sectoral structure of agricultural production with a relative excess of land resources, taking into account the peculiarities of the soil and climatic conditions of non-black soil regions, is the development of dairy and beef cattle breeding. The main forage crops for cattle are perennial legumes and cereal grasses. The feed obtained from them has a sufficient protein content at half the cost of a feed unit than the feed from grain produced under non-black soil conditions.

With more intensive use of at least half of the area of arable land occupied by perennial grasses, it is possible to provide an additional 100,000 conditioned cattle, increasing livestock by about half and respectively doubling the production of milk and meat. To do this, it is necessary to add sections of perennial grasses to crop rotations and update the grass stand.

The development of cattle breeding will also allow the increased introduction of organic fertilizers, which will stabilize the level of soil fertility and increase the efficiency of crop production. Nevertheless, this requires significant investments in the construction of livestock buildings; the purchase of technical equipment, including for feed production; the formation of working capital; and the solution of social problems in connection with the need to attract an additional number of workers.

The amount of necessary investments for increasing the number of cattle by 100 thousand conditional animals will equal, at our estimates, at least ₽ 20 billion. It is unlikely that it will be possible to find it in the coming years—but this direction of improving the sectoral structure is the main one.

The problem is also that, if in the coming years, the periodic cultivation of the soil on the area of arable land that has not yet suffered from the bush formation is resumed, the process of its degradation will not be stopped.

According to certain scholars [5], the costs of reclamation and development of shaded lands amount to ₽ 60 thousand/ha. If the actions aimed at stopping the degradation process are not taken, then in the next 5–7 years in the Tver region, there is a threat of arable land becoming overgrown with woody plants in the area of about 200 thousand hectares. For its reclamation and involvement in circulation, ₽ 12 billion will be required, which is comparable to the cost of developing livestock.

The expansion of commercial cereal crops cannot be considered as an alternative to the development of livestock. The average grain yield in the Tver region on average over the past 10 years amounted to 14.2 centner/ha, and with a system of disturbed fertilizer, it has no growth prospects. With the average cost of the crop at purchase prices at the level of 9–11 thousand ₽/ha, the minimum amount of expenses calculated using technological maps is 12 thousand ₽/ha.

In order to ensure more efficient use of arable land and stop the process of their retirement from circulation, it is more advisable to develop the production and primary processing of long-flax—a traditional industry of nonblack soil regions.

Significant investments are also necessary for the development of this industry—in the range of ₽ 2–3 billion per 10 thousand ha of additional crops. However, if flax sowings are placed on soils with a high level of fertility and intensive cultivation and harvesting technologies are used, there are good chances to ensure a return on the investment in an acceptable time frame [4].

The development of flax cultivation makes it possible to implement the important principle of increasing the efficiency of agriculture—more intensive use of land with a high level of fertility. In previous years, not only were the areas with soils of poor fertility eliminated from the turnover, where the costs of cultivating long flax and grains did not pay off with revenue, but also the fertile lands. This took place in the business that stopped production or sharply reduced its scope due to a shortage of labor and material and technical resources.

In the Tver region, among the arable lands that do not require reclamation but are not used or inefficiently used, the share of areas where it is possible to obtain an economically acceptable level of yield of at least 10 kg/ha is, according to our assessment, at least 20% or about 80 thousand hectares. Following the agrotechnical requirements, flax crops can be returned to their former place in no more than 6–8 years. That is, it is possible to increase flax crops by 10–12 thousand hectares.

Newly created specialized enterprises of the flax subcomplex should not acquire or lease arable land for long-term use. Then, they would have to carry out production in the entire complex of related industries, including livestock and feed production. The production base of a specialized enterprise for the production and primary processing of raw flax materials should include a flax mill and a machine and tractor park for the formation of mobile units for the cultivation and harvesting of flax in the leased areas within the territory of one or two administrative regions.

Nevertheless, for this, it is necessary to solve a whole complex of legal problems and create the opportunity to seize not only the unused agricultural land from the owners but also the inefficiently used.

The issue of land acquisition becomes relevant only if there are business entities that have intentions and economic abilities for its effective use in compliance with environmental requirements. With a temporary seizure of land for 1–2 years for the cultivation of long flax, the owners cannot be changed.

The expansion of crops of flax and the subsequent thinning of these sites will stop the degradation and overgrowing of the most fertile arable lands and create more favorable opportunities for the development of livestock.

In this regard, the increase of the cultivated area for the crops that require tillage will take several years (it is necessary to plow those areas of perennial grasses where there is a danger of bush formation) due to the limited investment opportunities. According to our estimates, the costs of soil cultivation and sowing of perennial herbs amount to 7.2 thousand ₽/ha.

4 Discussion

Many publications on the problem of more efficient use of agricultural land raise the issue of involving previously abandoned arable land in circulation [3, 7, 8]. Moreover, separate works analyze the reasons for retirement from circulation as well as the inappropriate use of farmland involved in the turnover, namely the farmers' lack of funds and resources [2]. According to some scholars, abandoned arable land is the primary reserve for increasing crop production [6]. Others believe that for the arable land remaining in cultivation, it is possible to increase agricultural production 1.5–2.0 times at a lower cost [1].

In the Tver region, the number of tractors per 1000 ha of crops is 3.5 times less than what is required by the standards for efficient production in this area. Obviously, in this situation, involving abandoned arable land can become practically necessary only in those farms and associations that have managed to attract investment for cattle breeding or flax growing.

Nowadays, in the non-black soil regions, the measures taken to stop the degradation of arable land are much more relevant, being based on improving the sectoral structure of the agricultural sector—the development of industries that ensure full and efficient use of agricultural land.

5 Conclusion

The main problem in the formation of the optimal sectoral structure of agricultural production in the nonblack earth regions of the country is the shortage of labor, material, technical, and financial resources that are necessary for the efficient use of arable land and other agricultural lands, as well as avoiding losses associated with their degradation.

The investments that can be attracted to agriculture in the nonblack soil areas should be directed to the development of dairy and beef cattle breeding and growing flax in the coming years. An urgent measure aimed at preventing economic losses associated with the degradation of arable land due to the bush formation is the return to the crop rotation of areas occupied by perennial grasses that have not been plowed for more than 4–5 years. It is advisable to occupy the most fertile of these areas by sowing flax crops and the less fertile by sowing cereals, followed by tilling and using the areas as pastures for several years until it becomes possible to use them more intensively in the field crop rotation.

References

1. Buzdalov, I.N.: Intensification of agriculture is necessary. AIC Econ. Manag. **4**, 10–22 (2013)
2. Mishina, Z.A.: The assessment of the possibility of involving unused agricultural land in circulation. Bull. Nizhny Novgorod Univ. Eng. Econ. **3**(58), 52–59 (2016)
3. Nikiforova, E.O.: Measures to involve unused agricultural land in circulation. Sci. Rev. Theor. Pract. **8**, 133–142 (2016)
4. Pozdnyakov, B.A., Velikanova, I.V.: Strategy for technical and technological renewal of flax growing in Russia. Econ. Agric. Process. Enterprises **2**, 22–25 (2018)
5. Shchukin, S.V., Golubeva, A.I., Dorokhova, V.I., Dugin, A.N.: Recommendations on involving unused agricultural lands in economic turnover. Bull. AIC Upper Volga **1**(41), 87–98 (2018)
6. Shishkina, N.V., Yushkova, V.E.: Evaluation of the Effectiveness of the Use of Agricultural Land in the Crop Complex of the Russian Federation. The Potential of the Development of the Russian Agricultural Sector: A Collection of Scientific Papers. Voronezh State Agrarian University, Voronezh, Russia (2013)
7. Vershinin, V.V., Petrov, V.A.: Improving the mechanisms for the involvement of unused agricultural land in agricultural circulation. Land Relations Land Manag. **5**, 9–11 (2015)
8. Zhelyaskov, A.L., Denisova, N.S., Seturidze, D.E.: The economic feasibility of involving unused agricultural land in circulation. Russ. Bus. **15**(261), 85–94 (2014)

The Model of Statistical Assessment of Food Security

Elena N. Antamoshkina and Aleksey F. Rogachev

Abstract The paper focuses on the analysis of food security in the economic security system of the state and regions of Russia. The analysis of the views on food security among the Russian and foreign scholars allowed to develop a framework for assessing food security at the regional level of the economy. The methods of cognitive economic and mathematical modeling and the empirical model of statistical evaluation are the effective methods of the analysis of food security. The food security of the Volgograd region in 2017 is analyzed. The assessment is carried out using an integral indicator—the food security index (I_{fs}). In accordance with the established threshold values of the food security index (I_{fs}), it was determined that the food security of the region was at an acceptable level in 2017. The inconsistency of the food security index with the optimal value was associated with a high degree of differentiation of household incomes and a non-optimal structure of the consumer basket, in which a significant part of the expenditure is spent on food. The results of the analysis revealed the obstacles for ensuring the optimal food security level. The theoretical and methodological significance of the study and the proposed model of statistical assessment is to supplement the methodological tools and models of food safety analysis.

Keywords Food security · Assessment model · Food security index · Food supply · Consumption rates

1 Introduction

The priority direction of modern agrarian economic science is to conduct research aimed at developing the concept of food security in Russia. The issues of food security and access to food products are considered, in most countries in the world, as

E. N. Antamoshkina (✉) · A. F. Rogachev
Volgograd State Agrarian University, Volgograd, Russia
e-mail: antamoshkina@mail.ru

A. F. Rogachev
e-mail: rafr@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_51

independent of state geopolitics. The standard of living in the country and its regions depends on providing the population with high-quality and safe food products. The food supply of the population and the food security of the state should be sustainable, which will create the conditions for the planned replacement of imported food with Russian products and provide the population with high-quality and safe food products [9].

Special attention is paid to the issues of pricing policy and pricing in the agricultural sector, as the availability of food for the population is one of the factors of food security. When assessing food security, it also is advisable to take into account the influence of the factor of import substitution, considering the need for optimizing the production and consumption of food in accordance with national standards.

Some aspects of food security in the context of the theory and practice of sustainable development of Russian regions are considered in the works of Ulezko [12] and Yarkova and Svetlakov [14]. The analysis of the implementation of the state agrarian policy is contained in the publications of Altukhov et al. [1], and V. I. Nazarenko. The current hot direction of research is the definition and evaluation of food security.

In the work of many international scholars (B. Senauer, P. Pardey, M. Rozegrant), the views on food security coincide with the point of view of the UN, which is concerned about the problem of hunger in developing countries. In this context, food security is obtained by combating hunger and preventing dependence on external food aid. In the works of W. Falcon and R. Naylor, food security is determined by three factors: the number of food suppliers (supply), the incomes of the population (demand), and the access of the population to food products (market). Another aspect of food security is its consideration as a specific public good supplied by agriculture. This approach is presented in the works of R. Branstad, E. Verdal, and I. Gaasland.

A description of the organization of the food supply system and the control of food safety and quality in Europe, the USA, and Canada and the regulatory and support measures for the agri-food sector of the economy are presented and analyzed in detail in the works of Herforth and Gill [8], Grace et al. [7], Weikard [13], Capone et al. [5, 6]. The large-scale interest in the problems of assessing and forecasting the level of food security has led to the emergence of various methods and models of assessment. Still, most of them are focused on the description of particular aspects of food security. The lack of objectivity in the results of the analysis is caused by the fact that most of them are not formalized, often based on expert estimates.

There is a lack of approaches for constructing dynamic cognitive models of food security that are based on a fuzzy cognitive approach. Moreover, they are used for solving multicriteria optimization problems, including high dimensionality. Methods of in-depth research and forecasting of the situation development are required, including a scenario approach to the formation of saturation and availability of the agricultural and food market; assessment of the level of threats to the sustainability of food security of Russian regions; design of countermeasures; and mitigation of negative consequences, as well as optimization of strategic food stocks.

2 Materials and Methods

2.1 Cognitive Economic and Mathematical Modeling

In order to justify the groups of factors and the system of food safety indicators, an expert method of hierarchy analysis should be applied. Based on the obtained system of indicators, the structure, relationships, and membership functions of fuzzy cognitive maps are formed. We use the construction of infological and information models for the parameterization of the cognitive maps. It provides justification for the structure of the relational database according to the analyzed statistical indicators.

The construction and verification of a family of predictive econometric models are carried out on the basis of particular indicators for food groups [4]. The techniques for integrating the resulting econometric models into the cognitive map can be developed based on membership functions and fuzzy logic. It is advisable to carry out the construction, testing, and debugging of a specialized software package, which implements pulsed modeling of the analyzed systems, on the basis of incidence matrices corresponding to cognitive maps. As a result, a scenario analysis of food security will be carried out using the constructed fuzzy cognitive maps.

A software package is needed to support numerical research and scenario analysis using the developed cognitive maps. Such a set of programs should include a computer program, a knowledge base for constructing the membership functions of factors, and a statistical database for research that is based on the use of an intelligent system for assessing and predicting the integral level of food security.

In order to create an intelligent system with a multi-criteria assessment for forecasting the food security level of the state and individual regions on the basis of a fuzzy cognitive approach, it is necessary:

- to substantiate the theoretical and methodological basis of an integrated assessment of food security;
- to form a system of indicators and a methodology for constructing fuzzy production cognitive maps for assessing the forecast for ensuring food safety, taking into account the areas of production, consumption, reservation, and import;
- to develop the methods and construction of membership functions for food safety factors, taking into account in-production cognitive maps;
- to build a system of fuzzy cognitive maps for assessing the level of food security at the state and individual regions;
- to model the self-development and controlled development of the food security system using the obtained cognitive maps for subjects of various levels;
- to develop a software package for monitoring and assessing the level of food security, predicting its dynamics.

The fulfillment of these subtasks will allow us to solve the problem of an objective integrated assessment of the level of food security based on the intellectual cognitive system, as well as to evaluate the dynamics of its change while taking into account management by state bodies.

2.2 The Empirical Model of Estimation Based on Statistics Indicators

In order to assess food security, a methodology is proposed [3], which involves the use of statistical indicators and the analysis of:

- the level of food self-sufficiency;
- the satisfaction degree of the physiological needs of the population for food;
- the level of food affordability.

Food self-sufficiency for certain types of agricultural products is determined on the basis of the self-sufficiency coefficient (C_s). The indicators are calculated as the coefficient of actual production volumes to the required volumes of food production in accordance with rational consumption standards. Using these coefficients, it is possible to establish the extent to which the needs of the population of the region are met on the basis of local food production.

The degree of satisfaction of the physiological needs of the population in food products is estimated using the coefficients of actual food consumption (C_{fc})—actual consumption is compared with rational norms [2].

The level of food affordability is determined by the ability of the population to purchase food. In order to characterize it, one should take into account the level of cash incomes of the population and food prices. The calculation of economic affordability is based on a scorecard [3]:

- the poverty rate (C_p)—the proportion of the population with incomes below the subsistence level;
- the consumption coefficient (C_c)—the share of food expenses in the structure of consumer spending;
- the Gini coefficient (C_g).

In order to assess the food security level, it is necessary to determine the integral indicator, the food security index (I_{fs}): $= C_s + C_{fc} + C_p + C_c + C_g$, as the sum of the scores for each of the analyzed indicators and to correlate the obtained value with the food safety criteria (Table 1).

The proposed model allows, on the basis of official statistics, to assess the achieved level of food security in the context of individual regions, carry out a comparative analysis, and determine the degree of differentiation in the food supply.

Table 1 Food security criteria

Points	The level of food security
>9	Optimal
5–8	Acceptable
<5	Low

Source [3]

3 Results

Let us use the model of statistical assessment of food security for determining the level of food security of the Volgograd region. Currently, the Volgograd region is among the 10 largest agricultural producers in Russia and the Southern Federal District (SFD).

Let us analyze the self-sufficiency of the region with the main types of agricultural products. This requires data on the rational food consumption standards (q_p) and the population of the Volgograd region (n), which, as of January 1, 2017, amounted to 2 million and 535 thousand people.

For example, for vegetables and vegetable products, the self-sufficiency coefficient was 2.9 (Table 2). The high value of this indicator shows that the Volgograd region not only fully satisfies its own needs through local production but also has excellent opportunities to supply vegetables to other Russian regions.

In 2017, the Volgograd region was the leader in the production of vegetables in the Southern Federal District and ranked second in Russia [11]. In potato production, the Volgograd region ranks third in the Southern Federal District behind the Krasnodar and Rostov regions. Despite the increase in productivity, the volume of potato production has essentially not changed over the past five years, varying between 393.6 and 428.3 thousand tons. This is caused by a small reduction in the cultivated area occupied by this crop, from 34 thousand hectares in 2013 to 32 thousand in 2016.

Milk and dairy products play a crucial role in ensuring the healthy nutrition of the country's population. In 2017, milk production in the Volgograd region increased compared to 2016, though by only 1.9%. According to this indicator, the region is still in third place, significantly inferior to the Krasnodar and Rostov regions.

In meat and milk production, the Volgograd region ranks third in the Southern Federal District, again significantly inferior to the Krasnodar and Rostov regions. However, there is a positive trend of a steady increase in meat production, which increased from 145.8 thousand tons in 2010 to 158.3 thousand in 2017 [11].

Table 2 The coefficients of self-sufficiency of the Volgograd region with food products

Type of product	The actual production volume, thousand tons (q)	Necessary production volumes, calculated in accordance with rational consumption standards ($n * q_p$)	$C_s = \frac{q}{n * q_p}$
Vegetables	1029.9	355.0	2.9
Potato	393.6	228.2	1.7
Milk	525.3	824.1	0.6
Meat	158.3	185.1	0.9
Eggs (mln.pcs)	817.9	659.3	1.2

Source Compiled by the authors according to the Rosstat data [11]

The analysis shows positive trends in the development of agriculture in the Volgograd region, which is able to satisfy the needs of the region's population in almost all basic food products (except milk and dairy products). In general, the total coefficient of self-sufficiency of the Volgograd region in 2017 was 1.46, which corresponds to the optimal level ($C_s > 0.9$), and can be estimated for the region at 2 points [3].

4 Discussion

The analysis of the volume of consumption of basic food products in the Volgograd region in 2017 allows us to draw a number of conclusions about the structure of the consumer diet of the population and its lack of balance. The consumption volumes of bread and bakery products (flour, cereals, rice, pasta, and legumes belong to this category) exceed the average volume of consumption in Russia and rational consumption norms of bakery products consumption (Table 3).

Based on the calculated coefficients of actual food consumption, it was found that this indicator in 2017 amounted to 1.09 for the Volgograd region. This corresponds to the optimal level ($I_{fs} > 0.95$) and can be estimated at two points for the region.

Let us assess the level of food affordability. In the Volgograd region, the size of per capita cash income in 2017 increased and amounted to ₽ 21,357, which is 72nd place among the Russian regions. Despite the increase in per capita cash income in the Volgograd region in 2017, the level of cash income remains below the indicators of 2015 (Table 4).

Table 3 The food consumption in the Southern Federal District and the Volgograd Region in 2017 (on average per household member per year; kg)

The subject of Russia	Bread products	Meat products	Milk products	Eggs, pcs	Sugar	Vegetable oil
Russia	117	75	231	279	39	13.9
Southern Federal District	119	75	216	306	42	14.6
Volgograd region	117	75	195	313	35	12.8
Rational consumption norms[a]	96	73	325	260	24	12
I_{fs}	1.21	1.02	0.60	1.20	1.45	1.06

[a]Order of the Ministry of Health and Social Development of Russia "On approval of recommendations on rational food consumption standards that meet modern requirements for a healthy diet" (August 19, 2016 No. 614). Retrieved from https://docs.cntd.ru/document/420374878
Source Compiled by the authors according to the Rosstat data [11]

Table 4 The dynamics of the population with incomes below the subsistence level in the Southern Federal District and the Volgograd region, in % of the total population

The subject of Russia	2015	2016	2017
Russia	13.3	13.3	13.2
Southern Federal District	17.5	17.4	16.2
Volgograd region	14.7	15.3	14.4

Source Calculated by the authors according to the Rosstat data [11]

As can be seen from the table, in the Volgograd region in 2017, the population with incomes below the subsistence level was 14.4%, the poverty level of the population decreased by 0.9%, compared to the previous year. This indicator was also higher than similar parameters for the subjects of the Southern Federal District (Rostov region, Krasnodar region, and Sevastopol). The highest poverty level is traditionally demonstrated by Kalmykia. Here, more than 27.3% of the population had incomes below the subsistence level.

In general, the poverty rate for the Volgograd region in 2017 amounted to 0.14, which corresponds to the optimal level ($C_p \leq 0.2$) and can be estimated at two points [3].

The second indicator for assessing the affordability of food is the coefficient of consumption (C_c). In 2017, in the Volgograd region, the food expenses amounted to 35.6%. The share of food expenses in consumer spending in other entities of the Southern Federal District is even higher: in the Krasnodar region—35.9%, Rostov region—38.1%, the Republic of Kalmykia—34.9%, Astrakhan region—40.6%, Crimea—46.2% and Sevastopol—52.7% [11].

A high share of food costs in consumer spending is not typical for developed countries (where this figure is at the level of 10–20%) and even for some developing countries (for example, Brazil—17.8%). In poor families, a third of the household budget is spent on food products. If spendings on food take 50% or more, this is an indicator of extreme poverty. According to some authors, a decent family life begins when its spendings on food are less than 30% [10]. On the whole, the share of food expenses in total consumer spending ranging from 25 to 50% corresponds to the permissible level (optimally, this is less than 25%) and can be estimated at one point for the Volgograd region.

The Gini coefficient in 2017 equaled to 0.342 for the Volgograd region. This corresponds to an acceptable level (optimal—less than 0.3) and is estimated at 1 point. In order to assess food security in the Volgograd region in 2017, it is necessary to determine the integral indicator (Table 5).

Table 5 The index of food security in the Volgograd region

Indicator value	Points
(1) Food self-sufficiency coefficient, $C_s = 1.46$	2
(2) Actual consumption coefficient, $C_{fc} = 1.09$	2
(3) Poverty coefficient, $C_p = 0.14$	2
(4) The consumption coefficient, $C_c = 0.356$	1
(5) The Gini coefficient, $C_g = 0.342$	1
	8 points

Source Calculated by the authors

5 Conclusion

The food security of the Volgograd region in 2017 was at an acceptable level. The deviation of the food security index from the optimal value is associated with a significant differentiation of incomes in the population and a high proportion of consumer spending on food.

The analysis revealed a number of factors that impede the achievement of optimal food security in the Volgograd region. These are an insufficient level of production of dairy and meat products; non-optimal structure of the commodity bundle, in which a significant portion of the expenditure is on food; and a high level of differentiation of incomes of the population, which affects consumption and living standards in the region and determines the need to establish food affordability by measures that ensure the growth of incomes and reduce their differentiation. Economic policy in the region, including agricultural, should be instituted, taking into account the need for correcting the above problems, which involves state support and stimulating the agricultural sector of the economy.

The assessment model used allows for analyzing food security based on real statistics, with the aim of subsequently defining measures for optimizing agricultural policy to ensure an acceptable level of food security in Russia.

Acknowledgements This paper was prepared with the financial support of the Russian Federal Property Fund for the project 19-07-01132 "Creating an intelligent system for assessing and predicting food security in the context of import substitution based on a fuzzy cognitive approach."

References

1. Altukhov, A.I., Anischenko, A.N., Artemova, E.I.: The Development Strategy of the Agricultural Sector of the Economy: Problems and Solutions. Prosveshcheniye – Yug, Krasnodar, Russia (2017)
2. Antamoshkina, E.N.: The assessment of food security in the Volgograd region. Bull. Volgograd State Univ. **3**(26), 16–24 (2014)
3. Antamoshkina, E.N.: The assessment of food security in the region: methodological issues. Food Policy Secur. **2**, 97–112 (2015)

4. Buyanova, M.E., Antamoshkina, E.N., Shlevkova, T.V.: Indicators of food security in the system of socio-economic diagnostics of the region. Retrieved from https://www.atlantis-press.com/proceedings/iscfec-18/55912594 (2018)
5. Capone, R., Bilali, H., Debs, P., Cardone, G., Driouech, N.: Food economic accessibility and affordability in the Mediterranean region: an exploratory assessment at micro and macro levels. J. Food Secur. **2**(1), 1–12 (2014)
6. Capone, R., Bilali, H., Debs, P., Cardone, G., Driouech, N.: Food system sustainability and food security: connecting the dots. Food Secur. **2**(1), 13–22 (2014)
7. Grace, D., Mahuku, G., Hoffmann, V.: International agricultural research to reduce food risks: case studies on aflatoxins. Food Secur. **7**(3), 569–582 (2015)
8. Herforth, A., Gill, M.: Strengthening the links between nutrition and health outcomes and agricultural research. Food Secur. **7**(3), 457–461 (2015)
9. Ministry of Health and Social Development of Russia (2016) Order "On the approval of recommendations on rational food consumption standards that meet modern requirements for a healthy diet" (August 19, 2016 No. 614). Retrieved from https://docs.cntd.ru/document/420374878/
10. Molchan, A.S., Ternavshchenko, K.O., Francisco, O.Yu.: The assessment of the level of food supply for the population of the Krasnodar region. Econ. Entrepreneurship **9**(1), 322–329 (2017)
11. Rosstat: Regions of Russia: Socio-economic Indicators. Rosstat, Moscow, Russia (2018)
12. Ulezko, A.V.: Food Resources Market in the Food Security System of the Far East. Voronezh State Agrarian University, Voronezh, Russia (2014)
13. Weikard, H.: Phosphorus recycling and food security in the long run: a conceptual modelling approach. Food Secur. **8**(2), 405–414 (2016)
14. Yarkova, T.M., Svetlakov, A.G.: Definition of state support for the generation of food stocks in the region in the WTO format. Econ. Reg. **4**(36), 157–166 (2013)

Regional Features of Food Security in Russia

Lidia S. Arkhipova, Irina V. Gorokhova, and Elena I. Kulikova

Abstract Providing the population with food is one of the most pressing problems of national security of all states in the world. Therefore, the problem of food security is as important and complex as, for example, national security issues. Its role in the functioning of the state is determined by the most important task—to preserve the nation's health now and in the future. In this regard, the aim of the study is to identify regional characteristics of food security in Russia and assess the role of the food industry in providing food to the population. The main research methods are indicative, statistical, analytical, and comparative. The paper analyzes the main indicators of food security. The authors identify the regions that provide the nationwide needs of the population for agricultural products and calculate the typology of regions according to the main indicators. The main findings of the study are the conclusion that the most favorable agro-climatic conditions and a favorable transport and geographical location are typical for a relatively small number of Russian regions that occupy leading positions in export–import operations in the food market. The novelty of the study is in the identification of the role of not only the leaders in the food production, but also those who, having no competitive advantages in natural and climatic factors, develop the food industry as the leading one in the system of processing industries of the non-primary sector. An important role of state food policy in ensuring food security in the country and its regions is noted. Therefore, the solution of many problems depends on the authorities' ability to confront and eliminate challenges and threats, as well as to predetermine these problems in a timely manner.

Keywords Food security · Indicators · Typology of regions · Food supply

L. S. Arkhipova (✉) · I. V. Gorokhova
Plekhanov Russian University of Economics, Moscow, Russia
e-mail: lidia.arkhipova@mail.ru

I. V. Gorokhova
e-mail: iri12411@yandex.ru

E. I. Kulikova
Financial University Under the Government of the Russian Federation, Moscow, Russia
e-mail: kulikovae@ya.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_52

1 Introduction

Throughout the history of mankind, the provision of food has always been one of the most pressing problems of national security in all states of the world. Food security reflects, firstly, the social orientation towards the implementation of the most important human right—ensuring existence. As noted in Article 7 of the Constitution of the Russian Federation, “The Russian Federation is a social state whose policy is aimed at creating conditions ensuring a decent life and free human development” [4]. In this aspect, food security is the most important basis for supporting life. In current conditions in Russia, food security is not ensured for some basic types of food. Therefore, one of the most important national problems is the achievement of safety parameters for all types of food at the federal and regional levels. The solution to this problem should become the main component of Russia’s development strategy for the next 15–20 years.

Food security is the basis of the economic security of the country and its regions. Ensuring food security remains a multidimensional, complex, and relevant issue, despite many of its aspects having been solved in practice and in legal documents. This is caused by the fact that the problem is related to every citizen of the country, to each household, and to federal and regional authorities.

2 Materials and Methods

In modern conditions, various scientific approaches to food security have emerged. Most authors [2, 10, 13] emphasize that Russia’s food security is determined by the effective functioning of regional agro-industrial complexes, the competitiveness of domestic products in food markets, social living conditions in rural areas, etc. The level and quality of nutrition largely determine the health of the population and its life expectancy. Other scholars [5, 12] believe that it is preferable to fill the domestic market with domestic food in order to prevent threats to national food and economic security. Assessing the level of food security should be carried out by methods of economic analysis through a comprehensive study of both food production and consumption [3].

Food security is a complex economic category for which analysis and evaluation are possible with the help of indicative indicators in both kind and value terms. In this regard, indicators making it possible to diagnose the physical and economic availability of food products are of great importance. These indicators are discussed in the Doctrine of Food Security of the Russian Federation, approved on February 1, 2010 [11]. One of the indicators characterizing the sphere of consumption is “food consumption per capita.”

Russia is 2/3 of the northern country; however, it has unique natural and climatic conditions for the effective development of the agro-industrial complex (AIC). The specialization of the constituent entities of Russia has historically been formed under the influence of factors, such as environmental conditions, population, geographical location, provision of transport infrastructure, etc. [8]. Food production is also focused on these factors, but agroclimatic resources are more important. Based on the influence of these factors, we can distinguish the main macro-regions (federal districts), which, specializing in the production of a particular food line, make a great contribution to inter-regional integration in the field of food security.

One of the most important sectors ensuring the country's food security is the food industry. It has distinctive features, consisting of its prioritization of the regions' population, close interregional integration, as well as the ability to export products. However, the agro-climatic conditions for growing crops and the regional potential of agro-industrial complexes vary significantly across the country, while determining the regions' ability to ensure their food security. Moreover, the challenges and threats to food security are regionally specific. Therefore, regional authorities, when developing normative legal and strategic documents, rely on their own capabilities and the threshold criteria presented in the Food Security Doctrine 2010 (until 2020) and the draft of the new Doctrine developed by the Ministry of Agriculture of the Russian Federation in 2018.

As a criterion for assessing food security, the Doctrine uses such an indicator as "the share of domestic products in the total domestic market." According to the Ministry of Agriculture, since 2010, almost all of these indicators have been achieved, with the exception of milk (82.4% in 2017) and salt (63.6%) [1].

A clear definition of the threshold criteria for food security for each of the Russian regions is difficult due to several factors. However, in practice, it is possible to determine the level of food security based on the following indicative indicators calculated on the basis of open data from the Federal State Statistics Service of the Russian Federation:

- the production of certain types of food by federal districts;
- the share of the food industry in the total volume of shipped products of manufacturing industries by federal districts and regions;
- agricultural output per capita by region;
- export and import of food products by federal districts and regions.

3 Results

The largest macro-region producing the main products of the food industry is the Central Federal District (CFD). It produces almost 58% of sugar products, meat—53%, cereals—32.4%, flour—31.2%, vegetable oil—29.1%, bakery products—28%, beer—28.8%, butter—26.3%. The district is the leader in terms of population (about 40 million people). In the south of the region, favorable agro-climatic conditions contribute to the development of the agro-industrial complex.

More than 50% of the total volume of shipped products of the processing complex accounted for food products, beverages, and tobacco products in three entities:

Belgorod (57.2%), Kursk (53.3%), and Tambov (54.7%) regions (Rosstat 2018), and more than 40% in the Voronezh (47.3%) and Bryansk (41.6%) regions. More than 30% of all processing industries accounted for the food industry in the Oryol (37.9%) and Vladimir (33.1%) regions.

The next macro-region with a high localization of the food industry is the Northwest Federal District (NWFD). The highest share of food products in the volume of shipped products of manufacturing industries is in the Pskov (46.8%), Murmansk (46.2%), and Kaliningrad (35.2%) regions. Northwest Russia produces 31% of canned and fresh fish (second to Far East Russia).

The climatic factor is the main favorable condition for food production in the Southern Federal District, where the activities of butter enterprises (28.3% of vegetable oils of Russia), sugar factories (23.3%), and cereal production (32.4%) are successfully distinguished.

Favorable natural factors are characteristic of the central and southern regions of the Volga Federal District, where enterprises engaged in butter (34%) and vegetable oils production (25.3%), flour milling (17.6%), and brewing (29%) are located. The southern parts of Siberia, especially the Altai region, are the breadbasket of Russia. Therefore, the Siberian Federal District is one of the three leaders in the production of cereals (30.1%) and flour (21.8%). The fish and fish processing industries are geographically concentrated in the Far East (58.7%) and the Northwest (31%) (Rosstat 2018).

To assess the level of food security, we will carry out a typology of regions (in accordance with the Russian classifier of types of economic activity) by the share of food products, beverages, and tobacco products produced by the food industry (Table 1). The results showed that in half of the subjects, the share of the food industry is just 20%. This is due to the fact that 50% of the regions are located in the north of Russia. However, about a quarter of the regions of this group have relatively favorable agro-climatic conditions, as they are located in Central Russia and the adjacent Volga regions.

In 30 subjects, the share of the food industry in the manufacturing sector varies from 20 to 44%, with more than 40% in the third part of them. For the most part, this group includes the regions of the Russian Chernozem region (the south of the

Table 1 The typology of Russian regions by the share of food industry in manufacturing

The share of the food industry in the manufacturing sector, %	The number of regions	The region with the highest rate	The region with the minimal rate
0.7–20	43	Tomsk region	Yamal-Nenets Autonomous Okrug
20.7–43.7	30	Voronezh region	Leningrad region
53.3–95.7	12	Kamchatka region	Kursk region

Source [7]

Table 2 The typology of Russian regions in terms of per capita agricultural output, mln. [7]

The production volume per capita (mln. ₽)	The number of regions	The region with the highest rate	The region with the minimal rate
50–190	23	Krasnodar region	The Altai Republic
21–49.5	39	Pskov region	Transbaikal region
0.7–18.5	23	The Republic of Ingushetia	Moscow

country), where the traditional branch of specialization is the agro-industrial complex. There are exceptions—for example, the Republic of Sakha (Yakutia) and the Magadan Region, regions of the north focused on the processing of mining products and mining equipment. In the Magadan region, the fishing industry stands out.

In 12 entities, the share of the food industry in the manufacturing sector is more than 50%, and in 3 of them, more than 80%—Kamchatka Krai (95.7%), Chukotka Autonomous Okrug (90.9%), and the Altai Republic (80.4%). The specifics of the first two regions include the presence of a huge marine area—the largest fishing areas and, accordingly, the development of the fishing industry. This group of regions also includes the republics of the North Caucasus (the Kabardino-Balkarian Republic, the Republic of North Ossetia, the Republic of Adygea) and the subjects of the Chernozem Region (Belgorod, Kursk, and Tambov regions).

Thus, the highest share of the food industry in the structure of shipped products from manufacturing industries was formed in only 12 entities that have either the most favorable climatic conditions or a geographical location favorable for the development of the industry.

The ratio of agricultural production per capita is of great importance for the diagnosis of regional food security (Table 2).

According to this indicator, in terms of value, six subjects of the Russian Federation are leading with indicators from ₽100 to 190 million: Krasnodar, Belgorod, Volgograd, Kursk, and Rostov regions. Expanding the group of regions to the level of production in the amount of ₽50 million per capita, it can be noted that the number of such entities reached 23 in 2017. The vast majority are the regions of the Central Black Earth region, the Volga region, and the south of the country. They have a high level of food security.

The middle group includes subjects with indicators from ₽20 to 50 million. Their number is 39. These are mainly the northern regions of Central Russia, the southern part of the Urals, Siberia, and the Far East.

The group of regions with low agricultural production includes 23 constituent entities of Russia, half of them are located in the north of the country. The other half is differentiated from the city of Moscow (₽ 0.7 million per capita; low concentration of production and high population), Khabarovsky Krai (₽ 12.6 million per capita) to the Republic of Ingushetia (₽ 18.5 million per capita; agricultural production is approximately 0.1% of the Russian Federation, 73rd place in the country). It can be noted that almost half of the constituent entities of the Russian Federation are characterized by an average level of food security.

One of the relevant indicators of food security is the export and import of food products. In the conditions of economic sanctions (since 2014), increasing import substitution in the food market is one of the main strategic objectives of the domestic agricultural sector.

The analysis of export–import operations for a group of food products for 2016–2017 based on the data of the Federal Customs Service (FCS) indicates their increase in both cost and physical volumes. No significant structural changes have occurred. The main countries—trading partners in the export of Russian wheat and meslin (a mixture of wheat and rye flour), remain Egypt (+45%) and Turkey (+29.9%) [6].

The share of food in the value of Russia's imports by the end of 2017 amounted to 13% (in 2016—14%). The value of food imports in 2017 increased by 15% compared to 2016. The largest share in the value of food was fruit—16%, meat and meat offal—9%, dairy products—9%, alcoholic and non-alcoholic drinks—9%, vegetables—6%, and others [6].

An unfavorable market factor is the growth of exports, mainly in physical volumes, not in value. The growth in physical volumes of exports does not lead to a corresponding increase in revenue. This effect is mainly observed due to a change (relative decrease) in world prices for many categories of goods, and also, possibly, due to problems with Russian suppliers with access to foreign markets [9].

The Russian regional market for the import of food products and agricultural raw materials has its own characteristics. The main macroregion leading in imports is the Central Federal District. The share of food imports in 2017 amounted to 52.5% of all imports in this product group in the Russian Federation. This is due to the concentration of 40 million people on its territory (first place in the Russian Federation), the metropolitan position, the base of offices of the leading companies in the industry, and a favorable logistical location. However, the diagnosis of the share of food imports in value terms for the period from 2010 to 2017 indicates a decrease in its share by 3.1%. Two entities, Moscow and the Moscow region, dominate. The share of their imports is 65.1% and 19.2%, respectively [7].

The second place belongs to Northwest Russia (27.15% from the Russian Federation), where the main factor in the development of export–import operations is its favorable geographical position. The Kaliningrad region stands out: the macroregion's share is slightly less than 30% of the total value of imports of the Russian Federation. Among the regions, St. Petersburg, Kaliningrad, and Leningrad stand out. The shares of the import are, respectively, 60.5%, 25.3%, and 10.8%.

Third place is occupied by the Southern Federal District (10.4%), where port facilities and transit railways cross the country from east to west and from north to south. Additionally, the district is characterized by the presence of favorable conditions for the agricultural sector. In value terms, the district's share in food imports grew by 3.4%. The leading position in food imports is occupied by the Krasnodar region (81%) and the Rostov region (13.9%).

The Siberian and Far Eastern federal districts did not increase their food imports as significantly as the South. Due to their geographical positions, these eastern macro-regions, giants across the territory, gravitate toward the Asia–Pacific region, in which there is either insignificant sanction pressure or none at all. However, their shares are not comparable with those of the Center and North-West regions, which have large financial resources and a powerful consumer factor. The Novosibirsk region (23.2%) and the Transbaikal region (35.7%) stand out in the Siberian Federal District. In the Far East, due to the advantageous transport and logistics factor, the Primorye region is the absolute leader (86.9%).

Among the constituent entities of the Russian Federation that are engaged in foreign trade of food products and raw materials for their production, fourteen regions can be distinguished. Their share in federal districts exceeds 20%. Among them, the Stavropol region and the Rostov region stand out, historically concentrating on agribusiness in their territories. Among the regions' major importers, the Primorye region stands out. It has one of the largest ports in Russia, Vladivostok, on its territory. Also, it has a special legal regime in the field of business and investment. Close in significance is the Krasnodar region.

4 Discussion

Thus, among the regions leading in export–import operations in food products, eight entities stand out that ensure the country's food security due to the effective development of the agricultural sector, the availability of production potential, and a favorable transport situation. These regions include Stavropol, Krasnodar, and Primorsky regions; Moscow and St. Petersburg; Sverdlovsk, Chelyabinsk, and Kaliningrad regions.

Discussion issues include the following questions:

- How can we solve the problem of advancing the physical volume of food exports compared with the proceeds?
- What are the prospects for solving the food problem in the northern remote regions in terms of their diversity and price range?
- What are the possibilities for diversifying the economies of those regions in whose structure the share of the food industry exceeds 50%?
- What management actions can increase food security in those regions that are at high risk?

5 Conclusion

Ensuring the food security of the regions in the Russian Federation is one of the key goals of the economy in the near future. Regional features of food security in the Russian Federation are closely related to the specifics of a particular region, expressed in specialization in the development of agriculture and the food industry in the central, southern, and southeastern regions. Favorable in scale sea areas and the favorable geopolitical position of the North-West and the Far East contribute to the development of not only import substitution, but also the expansion of foreign trade relations with new partners interested in products of the domestic food market.

The regions with a high level of food security include those that were among the leaders in all the indicators studied. These are the Krasnodar, Stavropol, Kamchatka, Altai, Rostov, and Kaliningrad regions. Among the regions characterized by a high level of threats in the field of food security, the Republic of Tyva, the Republic of Altai, the Arkhangelsk, Astrakhan, Novgorod, and the Tyumen regions with autonomous okrugs stand out.

State food policy also has certain features in ensuring food security in the regions. Therefore, ensuring food security in the regions and the state as a whole depends on the ability of authorities to solve this problem in a timely manner. The leadership of each region, enterprises of the respective branches of the regional economy, should make their own efforts to ensure food security on the scale of their territorial-administrative formation as a subject of the Russian Federation.

References

1. Agroinvestor: Analytics. A new food security doctrine has been developed. Retrieved from https://www.agroinvestor.ru/analytics/news/30159-razrabotana-novaya-doktrina-prodovolstvennoy-bezopasnosti/ (2018)
2. Altukhov, A.I.: National food security: the problem and solutions. Ministry of Agriculture of Russia, Moscow (2006)
3. Belkin, V.G., Uvarov, V.A., Shelepa, A.S.: Methodological approaches to determination of food independence of the region. Vestnik TSEU **1**, 3–10 (2012)
4. Constitution of the Russian Federation: Rossiiskaya Gazeta newspaper, Moscow (1993)
5. Dvornikov, V.A.: Economic security—theory and reality of threats. Publishing house of the IASP, Moscow (2000)
6. Federal Customs Service: Statistics of foreign trade of the Russian Federation. Retrieved from https://www.customs.ru/index.php?option=com_content&view=article&id=26274:2016 (2018)
7. Federal State Statistics Service: Regions of Russia: socio-economic indicators—2018. Retrieved from https://www.gks.ru (2018)
8. Gagarina, G.Yu., Chaynikova, L.N., Arkhipova, L.S.: Analysis of the sustainability of the socio-economic development of Russian regions. Federalism **1**(89), 104–121 (2018)
9. Institute for Comprehensive Strategic Studies (ICSI): Around statistics. Export and import of food products and agricultural raw materials. Retrieved from https://icss.ru/vokrug-statistiki/eksport-i-import-prodovolstvennyix-tovarov-i-selskoxozyajstvennogo-syirya (2018)
10. Ovchinnikov, V.N., Ketova, N.P., Lysochenko, A.A.: Greening of agricultural nature management—imperative of food security. J. Econ. Regul. **5**(2), 105–114 (2014)
11. Presidential Decree: Decree “On the Approval of the Doctrine of Food Security of the Russian Federation”, 30 Jan 2010, No. 120. Moscow (2010)
12. Rerich, V., Rerich, A.: On the system of state support of food supply in the Far North. Economist **8**, 82–89 (2000)
13. Senchagov, V.K.: Economic security of Russia. General course. Textbook. Delo, Moscow (2005)

The Assessment of the Level of Food Security in the Region

Inna V. Ryabova, Olga A. Frolova, and Alexey V. Pavlov

Abstract In the contemporary conditions, a lot of scholars' attention has been focused on the problem of food security, both in the country as a whole and in its individual regions. An assessment of the level of food security should be made both at the international and at the Russian level, i.e., at the level of the constituent entities of the Russian Federation. Appropriate management decisions to address food security issues must be adopted. The research paper clearly shows that there is no single methodology for assessing the level of food security in the region. As a result of generalization of existing approaches, the authors proposed a comprehensive assessment of the level of food security in the region. The proposed system of indicators was tested using the Nizhny Novgorod region as a case. A comprehensive analysis of the food security indicators of the region by basic food products allowed us to identify problems and priority areas for their solution. The study relies on analytical research methods, including mathematical and comparative analysis. The proposed methodology for assessing indicators characterizing food security criteria can be used in the regional agricultural management system at the federal and local levels.

Keywords Food security · Indicator · Criterion · Methodology · Physical and economic accessibility of food · Sufficiency of consumption · Food quality

I. V. Ryabova (✉) · O. A. Frolova · A. V. Pavlov
Nizhny Novgorod State University of Engineering and Economics, Knyaginino, Russia
e-mail: ryabova-inna-2012@yandex.ru

O. A. Frolova
e-mail: ekfakngiei@yandex.ru

A. V. Pavlov
e-mail: paval75.2008@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_53

1 Introduction

In the XXI century, the problem of food security, undoubtedly, remains one of the most global, acute, and pressing problems of all mankind. Without ensuring food security, it is practically impossible to solve any of the tasks facing the country, both at the federal and regional levels.

The role and importance of agricultural production in the food security system are reflected in the works: Baldev and Suslov [3], Vinogradov and Denisova [9], Dadalko [4], Zhurova [10], and Kleschevsky [5].

Food security of their own production is an important component of the process of ensuring the independence of territories, which necessitates the assessment of food security and systematization of indicators in accordance with the criteria of the doctrine of food security.

2 Materials and Methods

Currently, there is no single approach to assessing the food security of regional economies. We have studied the methods for assessing food security developed by Uskova [8], Antamoshkina [2], Olovyannikova [6], and Anischenko [1].

3 Results

The study of methods for assessing the food security of the region revealed their advantages and disadvantages. It was concluded that a complete assessment of each food security criterion is only possible by a set of indicators [7].

Having identified the shortcomings of the above methods, we systematized the indicators characterizing the food safety criteria (Table 1).

4 Discussion

The proposed system of indicators, providing a detailed and comprehensive analysis of food safety criteria, was tested in the Nizhny Novgorod region (Table 2).

The coefficient of self-sufficiency in grain for the analyzed period has a tendency to grow by 46.4%—due to an increase in grain production by 407,000 tons. It should be noted that the Nizhny Novgorod region covers only 41% of the existing needs of the region's population for grain products at the expense of its own production.

In 2017, the volume of meat production equaled 105.6 thousand tons, which is 10.6 thousand tons more than in 2013. As of the reporting date, the region provides

Table 1 Food Security Indicators

Food security criterion	Indicator
Physical availability of food	Self-sufficiency ratio Food import coverage ratio Actual food consumption ratio
Food affordability	Poverty rate The coefficient of purchasing power of income of the population of the region Gini coefficient Flow rate
Sufficiency of consumption	The ratio of nutrition structure Food sufficiency ratio
Food quality	Defects ratio

Source Compiled by the authors

59.2% of the population's meat needs from local production. However, it should be noted that the developed poultry industry in the region covers the consumption of other types of meat, namely beef and pork.

The reduction of gross milk production for the analyzed period by 1.5% led to a reduction in the coefficient of self-sufficiency in milk. In 2017, the Nizhny Novgorod region provided 63.4% of the needs of the region's population with milk of its own production.

Analyzing the situation of export–import relations in the region, we can conclude that the export of goods does not overlap their import; therefore, the coverage ratio of food imports over the entire studied dynamics turned out to be significantly less than one (except for the coverage ratio of grain imports in 2015).

Thus, in the reporting year, grain was imported 1.4 times more than exported, meat 6.9 times, and milk 2.0 times.

The coefficient of actual consumption of bread products in terms of grain in 2017 amounted to 1000 units. This value of the coefficient indicates that the actual level of consumption of bread products in terms of grain corresponds to rational consumption standards. In accordance with the order of the Ministry of Health of Russia dated 08.19.2016, the rational consumption rate of bread products is 96 kg, meat and meat products is 73 kg, and milk and dairy products are 325 kg.

In 2017, the annual consumption of meat and meat products by the population of the region amounted to 80 kg, which is 7 kg more than the rational consumption norms and 25 kg of the consumption norms of the consumer basket. The population of the region consumes 90 kg less than rational consumption standards.

An increase in the poverty rate by 10% is primarily due to an increase in the population, with cash incomes below the subsistence level by 8.9%. Despite the increase in the average per capita cash income of the population and the average monthly wage of workers, the number of people with cash income below the subsistence level in 2017 amounted to 322.8 thousand people, which is 26.5 thousand more than in 2013.

Table 2 Indicators of food security of the Nizhny Novgorod region

Indicator	2013	2014	2015	2016	2017
Physical availability of food					
Self-sufficiency ratio					
– Grain	0.280	0.346	0.353	0.348	0.410
– Meat	0.524	0.521	0.545	0.621	0.592
– Milk	0.636	0.646	0.648	0.627	0.634
Food import coverage ratio					
– Grain	0.571	0.674	1.261	0.893	0.716
– Meat	0.069	0.106	0.094	0.110	0.145
– Milk	0.357	0.358	0.431	0.439	0.491
Actual food consumption ratio					
– Grain	0.892	0.974	0.959	0.970	1.000
– Meat	1.000	1.000	1.000	1.055	1.096
– Milk	0.766	0.763	0.742	0.735	0.723
Food affordability					
Poverty rate	0.090	0.085	0.096	0.096	0.099
The coefficient of purchasing power of income of the population of the region	0.268	0.262	0.286	0.286	0.296
Gini coefficient	0.412	0.412	0.403	0.403	0.399
Flow rate	0.234	0.277	0.269	0.295	0.291
Sufficiency of food consumption					
The ratio of nutrition structure					
– Grain	0.893	0.973	0.955	0.964	0.991
– Meat	1.000	1.000	1.000	1.000	1.000
– Milk	0.850	0.846	0.823	0.816	0.802
– Average	0.914	0.940	0.926	0.927	0.931
Food sufficiency ratio	0.923	0.950	0.931	0.939	0.947
Food quality					
Defects ratio					
– Grain	0.999	0.972	0.987	0.947	0.930
– Meat	0.979	0.945	0.974	0.975	0.920
– Milk	0.929	0.984	0.963	0.960	0.977

Source developed by the authors

The coefficient of purchasing power of household incomes and the coefficient of expenditures in dynamics increased by 10.4% and 24.4%, respectively. The value of the coefficient of expenditures equal to 0.291 units suggests that the share of expenditures on food in the structure of household spending on final consumption was only 29.1%. Such a low value of this coefficient explains the deviation of the annual consumption of basic products per capita from the norms of the consumer basket.

The decrease in the differentiation of the population in 2003–2017 is confirmed by the dynamics of the Gini coefficient, which decreased from 0.421 units in 2013 to 0.399 units in 2017. Unfortunately, the indicators characterizing the situation of socially vulnerable groups of the population in the Nizhny Novgorod region have a negative trend.

When calculating the ratio of nutrition structure in the Nizhny Novgorod region, the following was taken into account: If the annual consumption of food products corresponded to or was higher than the consumption norms of the consumer basket, the value of the coefficient of the food structure was equated to one since the consumption rate for this product is fully met. It should be noted that the consumption of one of the products of the consumer basket above the norm cannot compensate for the consumption of other products.

Thus, the average value of the food structure coefficient for the three main groups of products in the consumer basket in 2017 was 0.931 units, which is 1.9% more than the level of the base year. The increase in this ratio is mainly due to compliance with the norms of meat and meat product consumption in the region.

The positive dynamics of growth in the actual consumption of Kcal per capita for these products contributed to the growth of the average food adequacy ratio, which increased by 2.6% over the analyzed period.

Assessing the quality of food in the Nizhny Novgorod region revealed that the largest number of rejected food raw materials and food products by volume were meat and meat products. Thus, the share of rejected dairy products in the region in the total volume of rejected products in 2017 was 2.3%, bread products 7%, and meat and meat products 8%.

5 Conclusion

The calculation of food safety indicators in the Nizhny Novgorod region revealed that the region does not provide for the needs of the population at the expense of its own production in such types of products as grain and milk. As a result, the annual consumption of bread products and milk per capita significantly lags behind the norms of the consumer basket. Imports of milk and grain do not cover the needs of the population in these products. The problem of malnutrition of some products cannot be solved by the consumption of others over the norms of the consumer basket. This situation is explained by the fact that the share of food expenses in the structure of household spending on final consumption is quite low. In the region, the population continues to grow with cash incomes below the subsistence level, which jeopardizes social policy.

The analysis of food safety indicators in the Nizhny Novgorod region made it possible to identify problems and identify priority areas for their achievement, which will contribute to the further development of draft state programs for the development of the region.

References

1. Anischenko, A.N.: Region food security assessment. Probl. Territory Dev. **4**(66), 30–39 (2013)
2. Antamoshkina, E.N.: Modeling and assessing the food security of the region. Bull. Lower Volga Agro-Univ. Complex: Sci. High. Prof. Educ. **1**(37), 239–244 (2015)
3. Baldov, D.V., Suslov, S.A.: The methodology for calculating food safety. Bull. Nizhny Novgorod State Univ. Eng. Econ. **1**(56), 13–26 (2016)
4. Dadalko, V.A.: Food Security as a component of the national and economic security of the state. Bull. UFA State Aviat. Tech. Univ. **7**(60), 17–25 (2013)
5. Kleschevsky, Yu.N.: Country food security assessment. Food Process. Tech. Technol. **3**(34), 163–169 (2014)
6. Olovyannikov, D.G.: The methodology for assessing the state of food security in the region by the example of the Republic of Buryatia. Bull. Irkutsk State Econ. Acad. **3**, 60–63 (2009)
7. Ryabova, I.V., Suslov, S.A.: The methodology for assessing regional food security. Azimuth Sci. Res. Econ. Manage. **3**(16), 173–177 (2016)
8. Uskova, T.V., Selimenkov, A.N., Anischenko, A.N., Chekavinsky, A.N.: Food security in the region. Institute of Socio-Economic Development of Territories of RAS, Vologda (2014)
9. Vinogradov, N.V., Denisova, N.V.: Agriculture of the country: structures and problems of functioning in modern conditions. Bull. Nizhny Novgorod State Univ. Eng. Econ. **9**(52), 39–42 (2015)
10. Zhurova, V.G.: Food security—an essential component of Russia's national security. Secur. Issues Russ. Soc. **4**, 22–25 (2013)

Food Security of Russia: Problems and Perspectives of Sustainable Development

Sergey V. Muzalev and Konstantin Y. Reshetov

Abstract In the context of the outlined trend of transition to a multipolar world, achieving a high level of food security is one of the main tasks facing the country's leadership at the present stage of development. The Food Security Doctrine of the Russian Federation (developed in 2010) made it possible to take certain steps towards improving food security, as one of the main elements of the state's national security. However, in the context of the constant impact on Russia of a number of Western countries expressed in the form of imposing sanctions, as well as reciprocal counter sanctions imposed by the Russian Federation, the requirements set forth in the Food Security Doctrine need to be reviewed. The current Doctrine of Food Security does not take into account many aspects that may affect the level of food security of a country. In modern conditions of the formation of a socially-oriented economy, it is necessary to take into account a number of positions reflecting the standard of living of the population when developing and updating legislative documents. Economic digitalization requires a transition to a new level of monitoring of the main criteria reflecting not only the level of state food security but also other macroeconomic indicators. Thus, today there is a need not only to adjust the current Doctrine of Food Security but also to amend a number of legislative documents based on large-scale research in this area with the involvement of specialists in various fields, both theorists and practitioners.

Keywords National security · Food security · Food security doctrine · Standard of living

S. V. Muzalev (✉)
Financial University under the Government of the Russian Federation, Moscow, Russian Federation
e-mail: msv.com@mail.ru

K. Y. Reshetov
National Institute of Business and Russian Presidential Academy of National Economy and Public Administration, Moscow, Russian Federation
e-mail: konstantvip@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_54

1 Introduction

In modern geopolitical conditions, ensuring national security and the socio-economic development of Russia is a paramount task of state policy that contributes to the effective protection of the country's national interests. Nowadays, the country has created a basis for the further growth of Russia's potential and its role in the changing polycentric world. The economic potential of Russia, given the instability of the world economy and the sanctions imposed by a number of countries against the Russian Federation, has demonstrated its ability to stabilize and gradually grow.

It is worth noting that the economic processes taking place both within the country and on the world stage are increasingly influenced by the political tools used by a number of countries to solve their geopolitical problems and leading to a decrease in the stability of the system of international economic relations. In order to prevent threats to Russia's national security, it is necessary to focus on strengthening domestic economic potential, as well as on raising the level of such national security subsystems as national defense, state and public security, improving the quality of life of citizens, etc. [5].

Improvement in the quality of life of citizens can be achieved by ensuring food security, which implies the mandatory achievement of food independence of the Russian Federation from other countries.

The Russian and international definitions of the term "food security" do not differ greatly from each other, though the Russian and international criteria for assessing food security differ quite seriously.

The Doctrine of Food Security of the Russian Federation approved by Decree of the President of the Russian Federation (January 01, 2010 No. 120) provides the following definition of food security: "Food security of the Russian Federation is the state of the economy of the country, which ensures food independence of the Russian Federation, guaranteeing physical and economic accessibility for every citizen of the country of food products that meet the requirements of the legislation of the Russian Federation on technical regulation, in volumes not less than the rational norms of food consumption necessary for an active and healthy lifestyle" [3].

However, the international definition of food security is based on the concept adopted at the World Food Summit held in Rome in 2009 and reads as follows: "Food security exists when all people always have physical, social, and economic access to sufficient safe and nutritious food to satisfy their diet needs and food preferences for an active and healthy life" [6].

Thus, it is obvious that the food security of Russia is interpreted mainly as food independence, i.e., "sustainable domestic food production in volumes not less than the established threshold values for its specific gravity in the commodity resources of the domestic market for the relevant products" [3]. It should be noted that in world practice, the main emphasis is made not on independence from food supplies from other countries, but on the ability of the population to have access to food in sufficient quantities and of adequate quality.

2 Materials and Methods

The main criterion for assessing food security in Russia is the share of domestic agricultural products in the total volume of commodity resources of the domestic market.

This criterion and others are presented in the Doctrine of Food Security of Russia until 2020. However, in January 2018, the Ministry of Agriculture, together with other departments, public unions, and associations, made a number of proposals for updating the existing Doctrine. Thus, for the first time, it was proposed to introduce production standards for domestic fruits and vegetables and increase the share of domestic oil, sugar, and fish (Fig. 1).

The calculation of the criteria for achieving the required level of food safety is based on the fulfillment of food consumption standards recommended by the Ministry of Health of the Russian Federation that meet modern requirements for a healthy diet (Fig. 2) [2].

According to the Ministry of Agriculture of Russia, after the introduction of the food embargo in 2014, the level of food security has increased significantly, but in 2018 three segments of the agricultural market still do not meet the criteria laid down in the Food Security Doctrine. Thus, the specific weight of milk equaled to 84.2%, which is 5.8% below the established criterion, the specific weight of potatoes—94.9%, which is slightly (0.1%) below the established criterion, but in terms of edible salt, there is a significant lag from the criterion, by 25.8% (64.2% at the rate of 85%).

All other indicators reach the required criteria level. However, it is worth noting that the definition of criteria at the moment is carried out only on those indicators

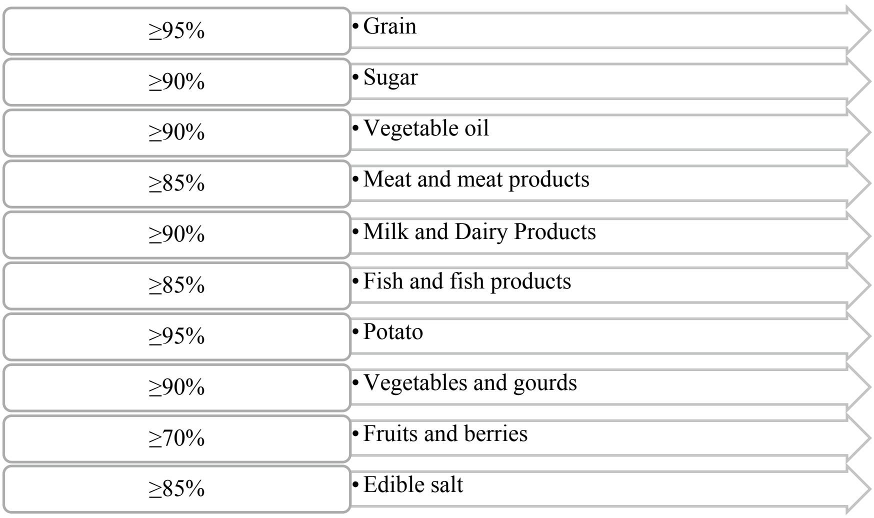

Fig. 1 Food security criteria in Russia (draft)

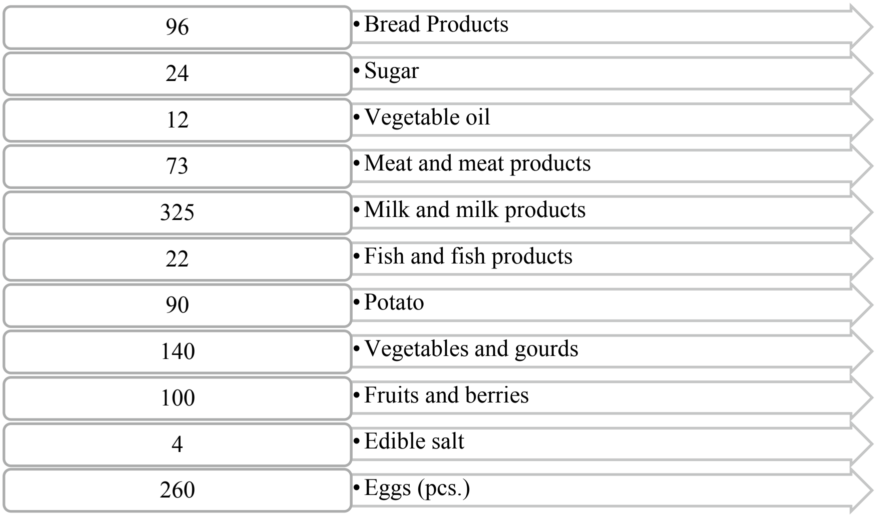

Fig. 2 Recommended rational food consumption standards that meet modern requirements for healthy eating in Russia (kilogram per person)

that are included in the Food Security Doctrine, and the proposed criteria as a project have not yet been investigated.

3 Results

Despite the fact that the data published by the Federal State Statistics Service and the Ministry of Agriculture indicate a positive trend in the criteria for food security in Russia over the past five years, it is worth noting that a number of problems point to several aspects that, in our opinion, are worth paying attention to.

The results of statistical data on the gross production of basic agricultural products are presented in Table 1.

If we consider the dynamics of the gross harvest of basic agricultural products, it is clear that compared with 2013, in 2018, there is an increase in all types of products, with the exception of potatoes. However, if we take into account the fact that in 2014, after the inclusion of the Republic of Crimea and the city of federal significance Sevastopol into the Russian Federation, the population of Russia increased by almost 2.5 million people, then the growth in production per capita becomes less noticeable (Table 2) [1].

If we consider food security in terms of the availability of quality food in order to meet the needs and food preferences of the population to lead an active and healthy life, the picture changes significantly.

Table 1 Gross production of basic agricultural products, thousand tons

Agricultural products	2013	2014	2015	2016	2017	2018
Cereals and legumes	92419	105212	104729	120677	135539	113255
Sugar beet	39292	33476	38989	51325	51913	42066
Sunflower seed	9852	8481	9289	11015	10481	12756
Potatoes	24021	24284	25406	22463	21708	22395
Vegetables	12597	12821	13185	13181	13612	13685
Gourds	1492	1531	1783	1884	1815	1970
Fruits	2737,8	2778,5	2675,3	3055,1	2682,6	3337,0
Cattle and poultry for slaughter	8525,3	9026,0	9518,5	9853,3	10319,0	10585,4
Milk	29865,3	29995,2	29887,5	29787,2	30184,5	30639,7
Eggs, mln. pcs	29865,3	29995,2	29887,5	29787,2	30184,5	30639,7

Source Developed by the authors based on Federal State Statistics Service [1]

Table 2 Dynamics of production of basic agricultural products, thousand tons

Agricultural products	2014	2018	Growth rate 2018/2014, %	Growth rate per capita 2018/2014, %
Cereals and legumes	105212	113255	107,64	105,30
Sugar beet	33476	42066	125,66	122,92
Sunflower seed	8481	12756	150,41	147,13
Potatoes	24284	22395	92,22	90,21
Vegetables	12821	13685	106,74	104,41
Gourds	1531	1970	128,67	125,87
Fruits	2778,5	3337,0	120,10	117,48
Cattle and poultry for slaughter	9026,0	10585,4	117,28	114,72
Milk	29995,2	30639,7	102,15	99,92
Eggs, mln. pcs	29995,2	30639,7	102,15	99,92

Source Compiled by the authors based on Federal State Statistics Service [1]

In accordance with Federal Law No. 227, "On the Consumer Basket as a whole in the Russian Federation" (March 12, 2012), the volume of food consumption is set (Table 3).

Thus, the rational food consumption standards recommended by the Ministry of Health that meet modern requirements for healthy eating are higher than the average food basket standards for all categories, with the exception of bread products. It should be noted that the level of consumption of such categories as vegetables, fruits, meat, and eggs is lower than the recommended norms by more than 20%.

Table 3 The volume of food consumption

Name	The volume of consumption (average per person per year)			The average consumption	The recommended rate of consumption
	Working age population	Retired people	Children		
Bread Products	126,5	98,2	76,6	110	96
Potatoes	100,4	80	88,1	93	90
Vegetables and gourds	114,6	98	112,5	110	140
Fresh fruits	60	45	118,1	67	100
Sugar	23,8	21,2	21,8	23	24
Meat and meat products	58,6	54	44	55	73
Fish and fish products	18,5	16	18,6	18	22
Milk and dairy products	290	257,8	360,7	295	325
Eggs (pcs.)	210	200	201	206	260
Vegetable oil	11	10	5	10	12
Other products	4,9	4,2	3,6	4	4

Source Compiled by the authors based on President of the Russian Federation [4]

Furthermore, considering the possibilities of the population to purchase food products defined in the grocery basket, we can see the following result (Table 4).

As can be seen from the presented material, the standard of living of the population has decreased, and the growth rate of incomes is lower than the growth rate of the cost of the minimum set of products. It is also worth noting that there is a negative trend when considering the average per capita income adjusted for the consumer price index.

4 Discussion

The results presented in the study suggest that food security in Russia at this stage has not been achieved. In the context of the transition to a socially-oriented economy, it is worth paying attention to the possibility of adjusting the criteria reflecting the achievement of the established level of food security in the country, as well as developing methods to monitor the level of food security, especially in the context of the global digitalization of the economy.

Table 4 Indicators of living standards, thousand

Agricultural products	2013	2014	2015	2016	2017	2018
The cost of a minimum set of food	2871,5	3297,9	3589,9	3701,9	3749,6	3989,2
Non-grocery goods	1435,7	1648,9	1794,9	1850,9	1874,8	1994,6
Services	1435,7	1648,9	1794,9	1850,9	1874,8	1994,6
Consumer basket	5742,9	6595,8	7179,8	7403,8	7499,3	7978,3
The living wage value	7306	8050	9701	9828	10,088	10,287
Per capita cash income	25928,2	27766,6	30466,6	30747	31421,6	32635
Consumer price index for goods and services	1,06	1,11	1,13	1,05	1,03	1,04
Per capita cash income adjusted for consumer price index	25928,2	26079,3	25698,4	22969,6	22273,0	22566,7
The proportion of the population with an income below the subsistence level, %	9,8	14,2	20,2	19,8	18,7	17,6

Source Compiled by the authors

5 Conclusion

Based on the above information, we would like to note that in modern conditions and in light of the requirements of the Russian Federation's President on the formation of a socially-oriented state, there is a need to adjust the Food Security Doctrine in a number of key areas. It is necessary to switch not from an import-substituting to an export-oriented doctrine, but rather from an import-substituting to a socially-oriented one.

First of all, it is necessary to adjust the approach to the very concept of "food security" and include in its definition the availability of agricultural products for various segments of the population.

Further, it is necessary to make changes to the minimum set of products included in the food basket, taking into account the recommendations of the Ministry of Health on the consumption of foods that meet the requirements of a healthy diet.

In order to assess the state of food security, develop and approve criteria that take into account not only the volume of production of products of a particular type but also the economic and physical availability of food.

It is necessary to bring the cost of the consumer basket in line with real prices in the context of each region of the country.

Moreover, there is a need to consider the possibility of redistributing income within social groups by making changes to the tax policy of the state by reducing the tax burden of the poor by increasing taxes on super incomes of certain categories of citizens.

In addition, it is worth paying attention not only to the volume of products produced by Russia's agricultural industry but also to the needs of agricultural organizations in terms of machinery, feeds, fertilizers, planting stocks, etc. This direction is also worth considering from the point of view of the state's ability to import substitution and introduce into the Doctrine of Food Security a criterion determining the level of dependence of agricultural organizations on the import of equipment, technologies, and materials necessary for production.

Thus, without ignoring the merits of the developed Food Security Doctrine, which, in fact, was a huge achievement in ensuring food security, it should be noted that it needs further processing to ensure adequate food security.

References

1. Federal State Statistics Service: Official Statistics. Retrieved from https://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/ (2019)
2. Minister of Health of the Russian Federation: Order "On the Approval of Recommendations on Rational Food Consumption Standards that Meet Modern Requirements for a Healthy Diet" (August 19, 2016 No. 614). Moscow (2016)
3. President of Russian Federation: Decree "On the Approval of the Food Security Doctrine of the Russian Federation" (January 30, 2010 No. 120). Moscow (2010)
4. President of Russian Federation: Federal Law "On the consumer basket in the whole of the Russian Federation" (December 3, 2012 No. 227). Moscow (2012)
5. President of Russian Federation: Decree "On the National Security Strategy of the Russian Federation" (December 31, 2015 No. 683). Moscow (2015)
6. World Food Security Summit: Declaration of the World Summit on Food Security. Retrieved from https://www.un.org/ru/documents/decl_conv/declarations/summit2009_declaration.shtml#a2 (2009)

Innovative Technologies and Practices in the Potato Product Subcomplex of the Russian Agricultural and Industrial Complex

Vladimir V. Tulcheev, Sergey V. Zhevora, and Maxsim Yu. Borisov

Abstract The role of small business forms (IFCs) is discussed in the paper, which includes personal commodity (private farms), farmers (peasant farms), and small agricultural organizations (agricultural enterprises). Taken all together, they supply the Russian market with more than 50–60% of agricultural products. In order to ensure food security and the sale of large homogeneous batches of the environmentally friendly varietal fresh and processed potato and vegetable products to the domestic and world markets with the lowest losses and costs, it is advisable to create specialized non-waste agricultural production and trade cooperatives, with their own retail network. The authors consider the Russian agricultural and industrial complex as a highly interconnected system with multiple actors.

Keywords Cooperation · Food security · Potato production and processing · Efficiency

1 Introduction

If we take the data of the Federal State Statistics Service from 13 years ago, according to the 2006 agricultural census, of the 31.2 million employed in agriculture, the share of private farms (private household farms, peasant farms, and small agricultural enterprises) accounted for 92.4% (or 28.8 million people), and medium and large agricultural enterprises made up only 7.6%, employing 2.9 million people [3]. The data of the agricultural census held in 2016 are unlikely to differ much since annually, up to 15–20% of unprofitable agricultural enterprises go bankrupt in Russia.

V. V. Tulcheev (✉) · S. V. Zhevora
Lorch Potato Research Institute, Moscow, Russia
e-mail: vtulcheev@list.ru

S. V. Zhevora
e-mail: zhevoraserg@yandex.ru

M. Yu. Borisov
Federal State Budgetary Educational Institution of Higher Education "Russian Agrarian Correspondence University", Balashikha, Russia

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_55

2 Methods

In studying the best practices for the creation and development of potato and vegetable cooperative and agro-industrial associations in Russia and abroad, the following research methods were used: statistical-economic, computational-constructive, monographic, abstract-logical, taking into account the dialectic knowledge of projects, new technologies, and phenomena.

3 Results

As a result of ill-conceived reforms of accelerated privatization and corporatization of the agro-industrial complex of the Russian Federation, ten-year planned relationships and unified production chains were "torn to shreds," and large industrial potato and open-field vegetable growing turned into small-scale units (producing up to 93–95% of potatoes and vegetables in the MPF). For example, reducing the industrial planting of tubers in the country from 1318 thousand hectares in 1990 to 300 thousand hectares in agricultural enterprises and peasant farms combined on average for 2016–2018, or 4.4 times. The restoration of the previous volumes, at the existing growth rate of industrial potato areas, will take 70 years. This is at a time when large retail chains and potato and vegetable processing plants do not want to work with the owners of IFC, exposing them to unbearable bonuses, which lead to further degradation of Russian agriculture due to the inability to buy new equipment and the absence of money and civilized markets.

The Agricultural Census (2016) showed that for the period 2016–2018, sown areas under potatoes in private farms decreased from 1709 to 1024 ha, or 685 thousand ha with the annual bankruptcy of unprofitable agricultural enterprises and peasant farms to 15–20% per year. That is, we can simply lose the domestic "second bread" of high quality on the table as a result of the reforms, as the destroyed industrial varietal seed production in the country has just begun to develop. To provide 1.3 million hectares of all crops with domestic seeds of higher reproductions in the amount of 5.0–6.0 million tons, it will take more than a decade.

The question of "Who will produce potatoes and open-ground vegetables industrially in the future?" remains open, as the area under cabbage, carrots, beets, and potatoes in agricultural organizations and peasant farms in 2018 remained at the level of 2016. As a result, the import of potatoes increased from 288 thousand tons in 2016 to 772 thousand tons in 2017, and to 543 thousand tons (for January–July) in 2018, and imports of vegetables are even more [1].

Thus, the complex problem of import substitution of open-ground vegetables, seeds, ware potatoes, potato products, and especially potato starch (the import of which exceeds 3–4 times all acceptable food safety thresholds in the country) will not be resolved quickly due to the state's current attitude toward potatoes and the lack of commercially available domestic potato and vegetable equipment. Additionally, regional seed-growing potato and vegetable centers in the country are being created, so far without cooperation with the elite-growing specialized peasant farms and other elite farms, and the Soviet diversified experimental farms (Agricultural Organizations) in which profitable livestock production was often covered by profit from the highly profitable seed production of potatoes (and other crops) are being destroyed.

Meanwhile, the owners of the IFC do not supply more than 70–80% of potatoes and vegetables in many dozens of amateur-made schemes and distribution systems. Using the advanced Russian (at the beginning of the twentieth century) cooperative movement (partnerships, cooperatives) and today's advanced progressive experience in organizing cooperatives in the EU on the basis of farms (in Russia on the basis of voluntary merchandising of IFCs), it is necessary to create almost every major village, Cossack village, mountain village, Kishlak, etc.

In Russia, in the territory of the EAEU, CIS, and other countries, specialized potato and fruit, berry, melon, grape, citrus, and other production and ACTC of the Scandinavian type with its own distribution network, have jumped over the 200 to 300-year-old struggle of Western farmers with speculators, intermediaries, processors, traders, large agricultural holdings and transnational agricultural corporations (TNCs).

The imperfection of the cooperative legislation in Russia, the long-obsolete law "On Agricultural Cooperation" (with an incomprehensible form of organization—the cooperative farm), the lack of statistical reporting of cooperatives does not contribute to the development of the SPTC, while farmers deliver potatoes, fruits, and vegetables to the EU market through their cooperatives (The Netherlands—98%, Sweden—68%, Germany—67%, France—57%, Italy—50%, Spain—47%, and Denmark—37%, including up to 20% through their own farmer cooperative stores, markets, and logistics centers [5].

Having their own special transport (with an isothermal body and tailgate) and a cheaper mobile retail network of "walking distance" (including the "Vegetables and Fruits" type of Soviet stores), farmer food markets, as well as small mobile distribution centers in the cities with their directors, sellers, and guards, the ACTC creates an alternative to large foreign and domestic trading networks that farmers from the West try to fight. They also fight them in our country as they often trade falsified products ("chemical," "synthetic," "genetically modified" food intended for the third world countries).

In Russia, which held first place in Europe by the number of cooperatives and shareholders in 1913, today's cooperation can be extended to 120,000 trademark household farms (each 3 ha in average) with a total area under potatoes of 360,000 hectares that, when ACTC is created, can be converted into peasant farms. Even with a yield of 30–40 t/ha, they can optionally integrate into the domestic and global market to 10–12 million tons of standard seed and ware tubers. Additionally, we can do in 1–2 years what farmers of the developed EU countries have been doing for centuries (through market barriers and bureaucratic barriers) by building prefabricated (in 30–40 days) seed and food storage complexes from light metal structures (LMS) of any capacity and paid back in 0.5–1.0 years.

A tremendous leap forward can be achieved through the creation of potato and vegetable ACTC, if its future founders are allocated not in paper but in the real 12 million shares (up to 5 ha) formed after the liquidation of collective farms and state farms, returning them again to agricultural circulation together with 40 million hectares of the abandoned arable land, which is not used in the interests of local authorities or anyone else.

In addition, in Russia, there are 21 million gardens, summer cottages, and garden plots (covering more than 60 million people) and 18 million private household plots (uniting up to 60 million more Russians). In total, about 40 million land plots (in which potato occupies up to 60–70% or more in the structure of sown areas) could be turned into peasant farms or private enterprises and become part of the ACTC with appropriate stimulation. Moreover, in Russia today, there are about 20 thousand agricultural enterprises and 150 thousand peasant farms (including 60 thousand "tracked" by the Ministry of Agriculture of the Russian Federation). On average, 31.2 million tons of potatoes were produced in all categories of farms in Russia in 2013–2016, including 25 million tons in private households, peasant farms (2.4), and agricultural enterprises (3.8), or 80.1%, 7.7%, and 12.2%, respectively. In total, IFCs (taking into account of small agricultural enterprises) produce in Russia—30.1 million tons, or more than 96% of the potatoes with technology far from the achievements of modern agriculture and technology, often without quality seeds, means of protection, etc. This, in all 83 rural regions, is advisable to voluntarily combine in ACTC in order to reduce the laboriousness of cultivating and harvesting potatoes and vegetables of open ground by 5–6 times, increase marketability by 2–3 times, and the quality of the "borsch set" (i.e., cabbage, carrot, beet, potato) with the introduction of the "consumer field" system (instead of dozens of amateurs), a unified state technological policy (washing, evacuating peeled potatoes and vegetables) using accepted resource-saving "general schemes" of goods distribution using agreed containers, packaging, specialized automobile and railway, water, and sea transport (with the required temperature and humidity regime and ventilation), and certificates harmonized with the member countries of the EAEU, CIS, BRICS, SCO, etc. [4].

Strengthening food and environmental security of Russia is the main goal that agricultural producers (private farms, peasant farms, and agricultural enterprises, whose integration into non-waste agricultural formations—Agricultural Consumer Trade Cooperative, Agro-industrial Parks, and Agro-industrial Associations) are designed to ensure: reduce up to 50% or more agricultural losses in the system "field (farm)—the consumer;" almost double the real consumption of Russians and the corresponding export of grain and potatoes (including products of their processing with high added value); centrally process annually up to 60 million tons of non-standard agricultural raw materials, purifications, and other organic waste of primary and secondary bulkheads; liberate large cities and industrial centers of the country, etc. (due to the removal of old private vegetable bases and processing plants loaded with 10–20% of domestic agricultural raw materials) from different problems (e.g., environmental, sanitary, transport, criminal, urban, social, and other); ensure the so-called set of "borsch," "soup," "salad," "fruit and berry," etc. for different social facilities (e.g., kindergartens, schools, hospitals, canteens, law enforcement agencies, prisons, military units, nursing homes, motels, rest houses, cafes, restaurants, etc.) with the quality varietal organic potato and vegetable products and other products to be freed up on garden plots and at home, in the state supply and catering enterprises (due to the industrial production of "borsch set," its cleaning and evacuation for 365 days a year, an additional hundreds of millions of man-hours for further breakthrough in the economy of the agro-industrial complex and other national economic complexes, in conditions of a shortage of labor resources, a natural decline in the population of the country, repeated demographic holes, etc.).

All this suggests that it is time to move from words to deeds and to begin to systematically restructure the Soviet agro-industrial complex and the entire national economy, which has existed for 70 years under the gross indicators, reorienting their activities to high final-market results related to the delivery of the final competitive-quality products to the domestic and world markets, with guaranteed provision of the population of large cities and industrial centers of the Russian Federation.

Stolypin emphasized that in carrying out agrarian reform, the government "did not rely on the wretched and drunk, but on the resilient and strong." As under Stolypin and today—after 100 years, Russia needs a strong, wealthy peasantry, a middle class in the village, which in all countries is a stronghold of order, tranquility, and health of the nation that feeds almost the whole world.

In turn, ACTC does not disconnect but combines the competing commodity of personal subsidiary plots, individual entrepreneurs, peasant farm enterprises, and small agricultural enterprises, making them more powerful and profitable in the domestic and world markets, especially if you have your own inexpensive retail network with the established (jointly with the regions) trading, with a margin of 50–100% of the prime cost (not 200–300%, which intermediaries and traders have today).

Thus, ACTC is a cooperative "collectivization" (the same collective farm, consisting of economically strong and strong-minded, free peasant farmers), capable of producing environmentally friendly potatoes, vegetables, fruits, and their processed products (which do not trust autonomous collective agricultural enterprises, intermediary urban bases and factories), once and for all, eliminating the contradictions between agricultural enterprises and peasant farms in the Russian Federation by peaceful economic methods on the basis of a fair competitive market.

The high pace of life of Russians in market conditions has long required the appearance of peeled potatoes in the trading network of Russia, and, best of all, peeled "borsch set" and other domestic "sets" and semi-finished products for fast cooking and nutrition, that are not widely produced neither by foreign nor domestic firms today.

The work experience of the ACTC "Bryansk Guild of Potato-Breeders and Processors" (consisting of 7 founders farmers with 7000 ha of potato plantings, modern storages with a total capacity of 180 thousand tons, and a plant for the production of mashed potatoes from non-standard tubers), with the delivery of washed, packed potatoes to large retail chains in Moscow, St. Petersburg, and other cities, showed that, with commercial preparation of washed ware potatoes for sale, the number of small, damaged, and other non-standard tubers account for up to 40% of the total crop. In turn, the experiments showed that when cleaning standard tubers in cities, the waste reaches up to 35–40%, depending on the shape of the tuber, the depth of the eye, and the cleaning method. On average, for 2015–2017, all categories of Russian farms sold 8.4 million tons, and for 2013–2017, 3.8 million tons were produced in agricultural enterprises and 2.4 million tons in collective farms, which totals to 6.2 million tons, which can be obtained from just 155 thousand ha with a yield of 40 t/ha in ACTC, AIP, and APO, with a total area of 500 ha, with storage facilities of 15–20 thousand tons in each of the 310 associations (or 3–4 units in 83 regions of Russia). If 40% of small and non-standard tubers are separated from the joint gross harvest (6.2 million tons), then we will have 2.5 million tons of waste +35% of potato peels from 4.2 million tons of the vacuumed potatoes conventionally sold by the agricultural associations and peasant farm enterprises to the consumers in the retail trade network of the country, or another 1.5 million tons. In total, we receive 4 million tons of potato waste alone (non-standard and peeling), which constitute 65% of the gross harvest of industrial potatoes, which annually disappear without a trace at city bases, landfills, and urban sewers. This is equal to 1.35 billion feed units sufficient for the production of 200 thousand tons of pork, or 1.2 million tons of milk, or 400 thousand tons of potato starch, sufficient for the consumers in the BRICS, SCO, ASEAN, etc. On average, for the period from 2014 to 2016, more than 500 thousand tons of milk, or 42% of 1.2 million tons, were imported into Russia from abroad. This could be obtained annually using only 4 million tons of potato waste for cattle feed, or 13% of the average annual gross harvest in the country (about 30 million tons). For the nutrition of 150 million people, 15 million tons of tubers are enough, or 2 times less, with the consumption of 100 kg/person/year. This suggests that up to 15 million tons of tubers in Russia are used irrationally.

The ACTC, based on the IFC, with its own distribution network (convenience stores, suburban logistics centers, farmer food markets, etc.,) can solve this problem on the abandoned 40 million hectares of arable land in the country faster and more reliably by providing the population with nearby stores, public catering enterprises, public services, and other consumer products, such as kvass, milk, or home delivery, like pizza, in high-rise courtyards.

Moreover, ACTC, combining 93% of potato and 90% of the vegetable area in the country occupied by the IFCs, can receive high-quality agricultural products from their founders, other nearby commodity private farms, peasant farms, private enterprises, and small farms (providing them with seeds and nets in advance) using cooperative transport, while destroying intermediaries, dealers, and speculators, who were never positive agricultural workers. Doing so would stimulate the growth of agricultural production among the peasants.

The European experience has shown that it is very difficult, and often impossible, to fight large trade networks on the issues of endless price increases, the numerous ways to obtain illegal bonuses from agricultural producers, and the falsification of food quality, if not to oppose (as did the European, especially Scandinavian countries) a rigid alternative in the form of the creation of farmers' production and ACTCs.

In addition to the quick payback of storage complexes in 0.5–1.0 year, due to the reduction of losses and direct sales of products, the founders of ACTC can almost double the profitability of the association by feeding animals and selling pig milk or meat, using up to 50–60% of waste from the borscht set mixed with combined feeds of often lower qualities, which are also constantly rising in price.

Today, the trading niche of french fries is occupied by *McDonald's*, mashed potatoes are produced by the foreign *Rollton* company, and *Barin potato chips* produced by *Ozyory CJSC* in the Ozyorsk district of the Moscow region are successfully competing with the American company *Frito Lay*, unifying the economy of the Kashirsky district at the lowest cost in the world. As for the inexpensive peeled, evacuated borscht set for catering, state supply, and shops, there is no one except the agricultural holding Dmitrov Vegetables that is trading in this niche today, although the profitability of potato production without a peel and its price exceeds washed potatoes by 2–3 times and is in high demand throughout the country, not just in the Moscow metropolitan area.

But for fair competition, the state should (as in the West) help to build food storages in the ACTC, as grants alone may not be enough, even if they are combined by 5–6 owners of peasant farms or other small business forms. So, over the past 6 years, since 2012, ₽ 1.1 billion, including ₽ 245 million, have been allocated in the Moscow region for grant support to the farmers' movement, in 2018 for 37 grants, or ₽ 6.6 million per 1 farmer [2].

Of course, these funds are not enough for the construction of the most expensive critical technological link—a modern warehouse with workshops for primary and final processing and processing of agricultural raw materials, in comparison with the cost of plows, planters, cultivators, and harvesting equipment, even if the farmers (or owners of the IFC) group up. On the other hand, it is unprofitable for each owner of the IFC to build a modern small storage facility, and there is no point in selling their hard work for nothing to intermediaries and speculators.

If necessary (the increased demand in the domestic and global markets), it is easy to turn already-peeled potatoes (instead of evacuating) into fried "crisp" or "French fries" or use them to make mashed potatoes. And the expensive, modified, non-standard starch can be produced using the technological lines for the processing of tubers into dry starch, which was developed at the Russian Research Institute of Starch Products with a capacity of 10, 50, 100, 200, and 500 tons of raw material per day, for any storage capacity.

When creating a cooperative on the basis of the IFC owners, the direct-flow harvesting of potatoes, carrots, beets, onions, and cabbage of various ripening periods can be introduced for the first time. The process of direct-flow harvesting includes alternately removing crops from the light, facilitating early production of soils (with minimal clogging of the pile of tubers) with a high-performance, self-propelled digger-loader, using heavy vehicles equipped with a low-damage movable bottom (conveyor) to unload crops into storage—possibly with the conveyor-loader TKK-30, which has an automatic change in the height from which the tubers fall on the mound or floor—in the section of storage, bins, etc., that are allocated to each member of the ACTC. Furthermore, accelerated cleaning on favorable days would eliminate manual labor in the field, preserve the crop, reduce by half the cost of potato sorting (which are carried out during the implementation period), reduce the damage and loss of products during storage—and therefore during the sale, which will bring considerable income—and finally, lessen waste.

4 Discussion

Thus, it is not a confrontation of commodity private farms (household, garden, and summer cottages), peasant farms, private farmers, and small farms that survive as best as they can but their voluntary association in the specialized potato and vegetable and other ACTCs. There is also a simultaneous possibility of purchasing wild plants (mushrooms, berries, nuts, etc.) to released bins, sections, and refrigerators of modern storage complexes with a capacity of 3–30 thousand tons, in which it is easier and cheaper to check any agricultural products for food safety than in 3–30 thousand outlets located somewhere without the appropriate storage space. In the "field (farm)—consumer" system, it's enough to use the adapted "Mercury" system in the ACTC, which is able to check the quality of agricultural products in any link of a single technological product chain, while excluding all intermediaries and resellers, and just speculators of agricultural products (which do not stimulate the growth of agricultural production), significantly reducing the number of controllers (and sometimes bribe takers) of the Rosselkhoznadzor, Rospotrebnadzor, and Roskachestvo.

5 Conclusion

If today's domestic agriculture is faster than other sectors of the economy, it reduces the dependence of the Russian economy on the world economy and contributes more to the country's budget and GDP than exports of weapons, IT technologies, products, etc. Due to the export currency, we can purchase the missing agricultural machinery and high-performance technological equipment for ACTC, Agro-industrial Parks, and Agro-industrial Associations not manufactured in Russia and continue the further development of advanced agricultural production, restoring the prestige of the great agrarian and industrial power in the modern world, entering the five most developed economies of the planet.

References

1. Krasilnikov, A.: Potato market. Potato Syst. **1**, 10–12 (2018)
2. Kravtsova, E.: Farmers took the floor. Mosc. Reg. Today **28**(4441), 3 (2019)
3. Plotnikov, V.: Russian farmer: socio-economic portrait. Moscow, Russia (2009)
4. Tulcheev, V.V., Lukin, D.N., Lukin, N.D.: Cooperation and integration of small business forms—the development prospect of agribusiness and the common agrarian market of the EAEU. AIC Econ., Manag. **7**, 22–31 (2017)
5. Tulcheev, V.V., Pryamov, S.B., Lukin, N.D., Mindrin, A.S., Yagfarov, O.M.: Innovative Organizational, Economic, Technical, and Technological Scientific Developments Implemented in Practice in the Field of Production, Storage, Processing, Commodity Preparation, and Sale of Potatoes in the Conditions of Cooperation and Integration. Russian Agricultural Academy, Moscow, Russia (2014)

The Development of a System of Principles for the Formation of Integrated Reporting in Agribusiness Organizations

Liudmila I. Khoruzhy, Tatyana N. Gupalova, and Yuriy N. Katkov

Abstract The paper focuses on the formation of integrated reporting in agro-industrial organizations using copyright principles. The purpose of the study is to develop a modern system of principles for the formation of integrated reporting with an emphasis on the sustainable development of agricultural organizations. Monographic, abstract-logical, economic-mathematical, and comparison methods served as the research methods. The authors pay particular attention to the issues related to the identification and selection of reporting principles that most closely match current economic realities. A scheme describing relationships between the goals of sustainable development of agribusiness organizations and integrated reporting through performance indicators is presented in the paper. The principles used for the formation of integrated reporting, which are proposed and consolidated in the system, will contribute to the formation of objective integrated reporting in the agricultural organizations, with the possibility of obtaining economic, environmental, and social information within the framework of sustainable development.

Keywords Integrated reporting · Agro-industrial complex · Accounting principles · Sustainable development

1 Introduction

Sustainable economic development in an unstable, goods-saturated global market requires knowledge in market positioning, in the allocation and modification of capital, in identifying risks and opportunities for the development of an organization based on the organization's values [4]. A modern reporting model should contribute

L. I. Khoruzhy · T. N. Gupalova · Y. N. Katkov (✉)
Russian State Agrarian University—MAA named after K.A. Timiryazev, Moscow, Russia
e-mail: kun95@yandex.ru

L. I. Khoruzhy
e-mail: dka1955@mail.ru

T. N. Gupalova
e-mail: gttn@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_56

to the development of the competitive advantages of organizations of the Russian agro-industrial complex and correspond with the requests of interested users for effective activities in the economic, social, and environmental areas.

For a systematic assessment of the performance of the reporting organization and the perception of the organization's objectives in the concept of sustainable development, it is necessary to group reporting indicators in three areas: economic development, environmental improvement, and maintenance of social stability (Fig. 1).

The principles are an integral part of the reporting methodology. Principle (from lat. principium—the beginning, the basis) is the basic, initial position of the theory, science, doctrine, etc. [6].

A principle is used to denote a general law or rule adopted or declared as a guide to action, an agreed position, or basis of conduct or practice.

The principles are formulated with a long-term perspective as a basis for assessing the effectiveness of the organization, but they are not fundamental.

In general, with the emergence of the market, the following basic reporting principles in the most ancient manifestations can be distinguished: (1) brevity; (2) capacity; (3) understandability of reporting for any person capable of reading; (4) focus on the future, i.e., predictability of reporting; (5) the unambiguity of the answer to the question of whether it is possible to trust the reporting capital to management [8].

Popper [11] formulated the principles to which the elements of any system should correspond, which are consistency, independence, necessity, and sufficiency.

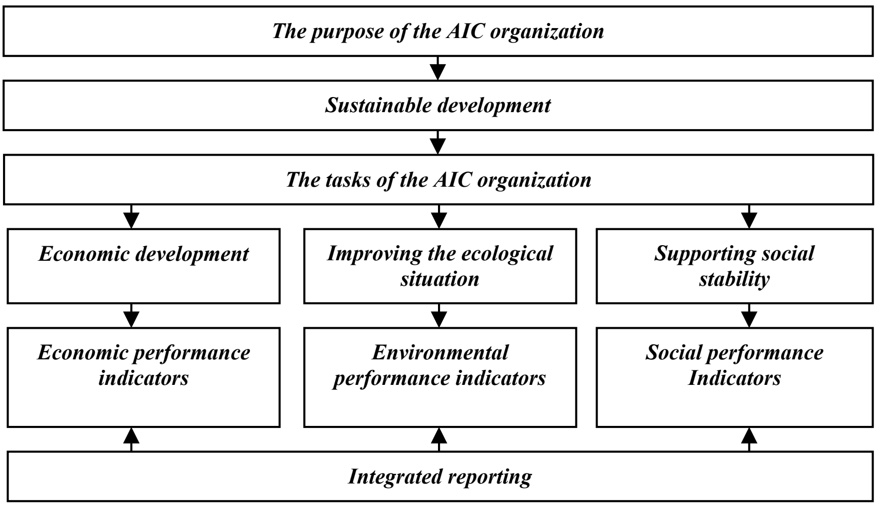

Fig. 1 The relationship between sustainable development goals and integrated reporting through performance indicators. *Source* Developed by the authors

Since the integrated reporting of agribusiness organizations is a system, its formation should use the core principle of consistency and the supplementing principles (independence, necessity, and sufficiency of reporting information).

2 Materials and Method

The principles of accounting are widely covered in the works of Belov [3], Dontsova [5], Getman [6], Ivashkevich [7], Piesengolz [10], Pyatov [12].

Among foreign scholars dealing with this issue, we can distinguish the following ones: Akerlof [1], Bell [2], Needles [9], and Spence [13], Upchurch [14]. In Soviet times, the following principles were used as the basis for the financial statements of agribusiness organizations [11]:

- reliability and accuracy of the indicators, confirmed by the relevant accounting records and primary documents;
- timeliness of preparation and reporting;
- simplicity, clarity, and accessibility of reporting for the workers, so they can participate in monitoring the work of the enterprise;
- the reduction and simplification of reporting;
- the reporting forms are approved by law, and the indicators are not supplemented or excluded by the reporting organization.

We believe that many of these principles can be used as a basis for the formation of integrated reporting of agricultural organizations. Moreover, they are based on the "eternal principles of accounting" (clarity, brevity, completeness, and fidelity) formulated by the outstanding Russian accountant F. V. Yezersky [15].

The aim of the study is to develop and substantiate a system of principles for the formation of integrated reporting with the emphasis on the sustainable development of agricultural formations.

The research methods include monographic, abstract-logical, economic-mathematical, and comparison methods.

3 Results

In order for the integrated reporting to meet the requirements of the managerial personnel of the AIC organizations, it is necessary that it follows these principles: consistency; independence; necessity; sufficiency of the system; the compliance of the reporting information with the requests of internal and external users; the reliability of the information; the timeliness of preparation and reporting presentation; and simplicity, clarity, and accessibility of reporting. These are the principles that we selected in the process of the previous analysis.

Having examined the principles of accounting, financial reporting, and management reporting, we can see that almost all of these fields are aimed at representing the organization's statics and only slightly concern long-term development trends.

But the pursuit of equilibrium is not a trend in the modern economy. It's about development. Therefore, reporting should represent the organization in dynamics and reflect the opportunities for the best use of existing opportunities for the economic, environmental, and social effectiveness of agricultural organizations.

Despite the fact that, so far, principles in the field of social reporting have been legally established only in some developed countries—for example, in England and France—Russian AIC organizations can voluntarily adopt the principles of social responsibility for business and assume responsibility for drawing up social reporting. Therefore, we will consider the principles of social reporting as approved in the form of standards in other countries and as proposed by Russian and foreign scholars.

In general, this study shows that, despite the deep theoretical development of the principles of accounting (financial and managerial) reporting and attempts to determine the principles of social reporting, they are not enough to form a globally-oriented integrated reporting of agribusiness organizations. The reason is the difference between the underlying goals.

In addition, the organization's reporting for one market entity or a homogeneous group of entities at the stages of market emergence and formation should have been based on the principles of rationalistic design. In addition, the corresponding function of integrated reporting, proposed by us, should allow the synergistic interactions of the agro-industrial complex organization and the environment, aimed at overcoming fragmentation and unilateralism businesses.

Accordingly, we considered it necessary to include additional principles in the integrated reporting system.

The principle of independence of the organization's economy requires the formation of integrated reporting for reflecting the viability of the organization and the possibility of independent sustainable development.

The principle of consistency requires the formation of integrated reporting for presenting to the interested users the patterns and relationships between the purpose of their activities, the resources available to achieve them, society, and the environment in the totality of reporting elements. So, as a result, consistency is a principle that guarantees that any information is verified, and conflicting information is clarified before the formation of integrated reporting. Necessity is a principle that implies the inclusion in the reporting of the information that is necessary only for the users. Sufficiency is the principle of a minimal, but sufficient, set of information in reporting.

The principle of multifunctionality is a principle that assumes the ability of integrated reporting to overlap the existing distinctions between different types of individual reporting organizations.

The effectiveness of the use of funds is a principle aimed at the organization's recognition of clear priorities in the expenditure of funds for pre-approved programs with broad powers for specific program executors. This entails the formation of the reports on the enlarged positions of the adopted programs in accordance with the priorities of the organization's strategy and the assessment of the achieved economic, environmental, and social results.

Noocentrism is one of the necessary principles of integrated reporting, orienting the organization to perceive itself as a reasonable organic part of the natural environment and not as its ruler as in the reporting models of the unsaturated markets, which are formed on the principle of anthropocentrism and not on the principle of biocentrism (which encourages the organization to perceive itself as an element of nature). The principle of noocentrism requires interrelation of the reported events and phenomena in the economic, environmental and social spheres: how the tax payments of the organization affect the development of the region of its activity and how the organization participates in local, regional, and federal projects that have a positive impact on the environmental and social situation, etc.

The principle of interaction with the external environment is the reporting principle, according to which moral factors in the organization's activities are recognized as a value. The reporting is based on the fact that the organization's activities do not lead to latent destructive impacts on nature and society.

The principle of flexibility predetermines the possibility of changing the form of the integrated reporting following the requests of internal and external users, but without a visible failure of the connection between its elements.

The principle of complementarity can be defined as the foundation of the existence of the whole, which represents the object most fully and embraces all reality in one model through the complementarity of the elements of the system.

The dynamism of positive influence is the principle aimed at distinguishing the reporting organization from other organizations for the development of a positive impact on the environment and social situation in the region where the business is carried out.

The openness to criticism means that the reporting organization has no intention of hiding its actions and projects; therefore, it does not need to hush up the problems, and there are no barriers to accepting the opinion of society.

Synergies—elements of integrated reporting should be formed in such a way as to mutually reinforce each other. This will lead to a bigger cumulative effect of the elements of integrated reporting on the reporting user than the effect of elements of other types of reporting. The reduction of the costs of generating up-to-date reporting is operational synergy. Information synergy will manifest itself through the effectiveness of information channels.

The principle of prognosticity is a principle aimed at the possibility for the user to predict the trajectory of the development of the organization based on the information presented in the reporting.

The principle of continuity is a principle that means connectivity, consistency of information across different reporting periods.

The principle of freedom from the influence of a polarizing business idea is the principle of denying the desire or need to distort the facts of economic life for the strategic purpose of the business in the actions of the reporting organization.

The principle of market segmentation is the principle aimed at structuring the information of integrated reporting on products (works, services) produced (provided) by the organization for consumers in the context of market positioning.

The principle of the matricity in the formation of integrated reporting is opposite to the hierarchy principle in financial statements and the principle of modularity in financial and management reporting. It means that each element is important only insofar as it serves to achieve the goal of integrated reporting. With the exception or addition of a separate element, the comprehensibility and transparency of the organization's actions for users of its reporting can be improved or, accordingly, it cannot be expanded or limited without ceasing to be systemic. The formation of integrated reporting, using the matrix principle proposed in this paper, will allow AIC organizations to designate the personal responsibility of the heads of many units working together according to the general plan, improve budgeting processes in responsibility centers—which will give ample opportunities when using non-standard calculation systems—eliminate duplication of functions, and increase the efficiency of agribusiness organizations in economic, environmental, and social aspects.

Such principles as freedom from the influence of a polarizing business idea, openness to criticism, materiality, accessibility, rationality, continuity of development, consistency, independence, necessity, sufficiency, multifunctionality, flexibility, synergy, and matricity are characteristic principles for the innovativeness of an organization and its products (works, services).

The compliance with user reporting requirements, interaction with the external environment, dynamism of positive impact, noocentrism, and complementarity are the principles aimed at characterizing the relationship of the organization with the external environment.

Based on the data contained in the accounting registers, efficiency of use of funds, frequency, accrual, timeliness, reliability, completeness, analyticity, simplicity and clarity, uniformity, predictability, continuity, brevity, consistency, and market segmentation are the principles aimed at characterizing the competitiveness of the organization.

4 Discussion

In general, the principles of reporting are the initial conceptual provisions of the reporting system, some of which (independence of the organization's economy; systematic, multifunctional, and efficient use of funds; noocentrism; interaction with the external environment; flexibility; complementarity; dynamism of a positive impact; openness to criticism; synergism; prognosticity; continuity; freedom from the influence of a polarizing business idea; segmentation; and matricity) are not inherent in other types of reporting organizations and offered here for the first time for an integrated report of the AIC organizations.

The principles developed differ from each other in terms of characteristics and values for practical use, and, therefore, should be classified. A classification can be defined as the distribution of objects of any kind into interconnected classes according to the essential features inherent in the objects of this kind and distinguishing them from objects of other kinds, with each class occupying a permanent place in the resulting system and, in turn, being divided into subclasses.

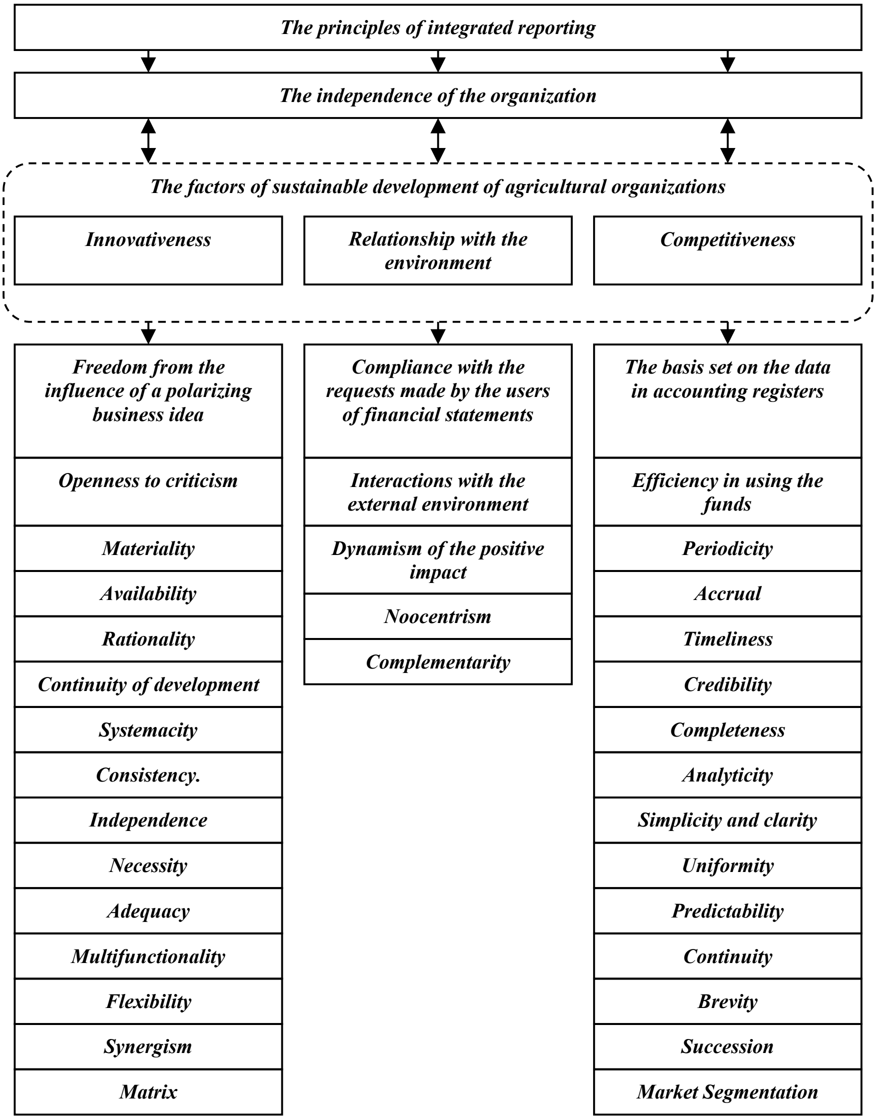

Fig. 2 The system of principles for the formation of integrated reporting with an emphasis on the sustainable development of agricultural organizations. *Source* Developed by the authors

The importance of classifying the principles for the formation of integrated reporting is the ability to see a general representation of the principles in all of their diversity and the relationships between them. If, in the grouping of principles of integrated reporting, we accept the requirements for reflecting innovation, the interconnections with the external environment and competitiveness in the model are formed, then the classification is based on the independence of the organization's economy. The first level is compliance with the requests of reporting users; the second level is the characteristics of the reporting requirements of a modern organization on innovation, environmental impact, and competitiveness.

Thus, the system of principles for the formation of integrated reporting with a focus on sustainable development of the AIC organization can be represented as follows (Fig. 2).

5 Conclusion

Formed on the basis of the developed principles, the integrated reporting of IAC organizations will be relieved of conditional values obtained as a result of all kinds of multiple data redistributions, which will, in turn, reduce the labor associated with reporting.

The proposed principles for the formation of integrated reporting will help agricultural organizations to provide:

- the correspondence of the corporate values with the values of social organizations;
- the ability to evaluate the performance of the organization in the future and compared to other organizations;
- representation of the organization's activities in economic, environmental, and social efficiency, i.e., as part of the implementation of the concept of sustainable development.

Thus, the results of the conducted study create a theoretical basis for the formation of integrated reporting by agricultural organizations, taking into account current economic conditions.

References

1. Akerlof, G.A.: The market for "lemons": quality uncertainty and the market mechanism. Q. J. Econ. **84**, 488–500 (1970)
2. Bell, D.: The Age of Disunity: Reflections About the World in the 21st Century. Free Thought, Moscow (2007)
3. Belov, N.G.: Sectoral aspects of the standardization of accounting. Account. Agric. **1**, 7–14 (2013)
4. Bogoviz, A.: Transforming the agricultural sector for better sustainable development: perspectives from Russia as a member state of the Eurasian Economic Union. IOP Conf. Ser. Earth Environ. Sci. **274**(1), 012001 (2019)
5. Dontsova, L.V.: Comprehensive Analysis of Financial Statements. Delo i servis, Moscow (2001)
6. Getman, V.G.: The urgent issues of improvement of accounting in Russia. Int. Account. **18**, 2–5 (2011)

7. Ivashkevich, V.B.: International financial reporting standards as a condition for increasing the investment attractiveness of an enterprise. Bull. Econ. Integr. **5**, 151–157 (2008)
8. Khoruzhy, L.I., Karzaeva, N.N., Katkov Yu, N., Tryastsina, N.Y., Ukolova, A.V.: Identification and presentation of information on sustainable development in accounting and analytical system of the organization. Int. J. Civ. Eng. Technol. **9**(10), 1575–1581 (2018)
9. Needles, B.: Accounting Principles (Trans. from English). Finance and Statistics, Moscow (2004)
10. Piesengolz, M.Z.: Agriculture Accounting: A Training Manual, vol. 2. Agropromizdat, Moscow (1987)
11. Popper, K.R.: Objective Knowledge: An Evolutionary Approach (Trans. from English). URSS, Moscow (2002)
12. Pyatov, M.L.: The theory of static balance as a method of presenting information about the financial position of an organization. Account. Agric. **4**, 46–51 (2011)
13. Spence, M.A.: Job market signaling. Q. J. Econ. **87**(3), 355–374 (1973)
14. Upchurch, A.: Management Accounting: Principles and Practice (Trans. from English). Finance and Statistics, Moscow (2002)
15. Yezersky, F.V.: Conversations of the trading and bookkeeping world. Schetovod, St. Petersburg (1876)

The Analytical Review of the Development Prospects of the Protected Horticulture in the Russian Federation

Natalia Devochkina, Rafael Nurmetov, and Oleg Razin

Abstract The authors assess the prospective development of protected horticulture in the Russian Federation. The protected ground of Russia is under the scrutiny of the state. The paper critically reviews the State Program for the Development of Agriculture and the Regulation of Agricultural Products, Raw Materials, and Food Markets for 2013–2020 was developed following the principles of ensuring food independence in Russia. The program focuses on the protected horticulture and defines the most important indicators of the annual production of off-season vegetable products by 2020 (1.72 million tons). Protected horticulture is one of the most capital-intensive, knowledge-intensive, and labor-intensive branches of agricultural production. Based on the analysis of global trends in the development of glasshouse horticulture, the general trends in the construction and organization of new enterprises in the industry are determined and presented in the paper. The modern approaches to technical and technological solutions are analyzed, allowing reaching a new level of labor productivity and ensuring high economic efficiency of production, achieving a full level of self-sufficiency of the Russian population with vegetable products by 75–80%.

Keywords Protected ground · Development potential · Glasshouse horticulture

1 Introduction

Protected horticulture in Russia is currently under active development. The industry is developing dynamically and efficiently; it is of great importance for supplying the population of the country with fresh vegetables, rich in vitamins and minerals, especially in the off-season period. In order to meet the needs of the Russian population in vegetable products from the protected soils, it is necessary to produce about 13 kg of vegetables per year per capita, but in reality, only 6.5 kg per year (2018) is produced per person. The average yield of vegetable crops in operating greenhouse complexes is extremely low, while the best greenhouse farms that have introduced the latest

N. Devochkina (✉) · R. Nurmetov · O. Razin
Federal Scientific Centre of Vegetable Growing, Moscow region, Russia
e-mail: green-hothouse@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_57

technologies into production have reached a level of at least 50 kg/m^2 of vegetable products and, in some cases, more than 80–100 kg/m^2 of vegetable products per year.

The intensification and modernization of the greenhouse horticulture industry is currently the main task requiring a quick and qualified solution. Increasing the efficiency and vegetable production of greenhouses is possible in two ways: through the reconstruction of existing greenhouse enterprises and the construction of new modern energy-saving greenhouse complexes, which can significantly reduce the energy consumption for the production of 1 kg of vegetables in winter greenhouses. Vegetable growing in protected ground in our country reached a significant peak in the early 80s of the twenty-first century when the area of winter and spring greenhouses reached seven thousand hectares. The global development trend of greenhouse horticulture indicates an almost-universal transition to intensive technologies and methods of growing plants in the closed ground with the use of the latest designs, equipment, materials, and energy-saving technologies. The intensive construction of new industrial greenhouses in the Russian Federation is also facilitated by a ban on the import of greenhouse vegetables from the bulk of the traditional importing countries into Russia for three consecutive years, and by high consumer demand for fresh vegetables during the off-season [4].

According to the calculations of RosGosstat, in order to provide the population of the Russian Federation with vegetables from protected soil, it is necessary to bring domestic production to 1.72 million tons. Today, taking into account the current level of production, this should amount to 0.8 million tons. The result is achievable with an almost double increase, as the current level is about one million tons [2]. The implementation of the industry development plan and the achievement of the indicated production volumes is possible with new construction of greenhouses in addition to the existing 2600 ha of winter glass greenhouses. Moreover, for the southern regions of Russia, there is considerable potential for using greenhouses of lightweight structures with plastic or film coatings that have been used for many years, the development of which is ensured by the leading Russian companies specializing in the production of greenhouse structures and equipment. A similar direction of the development is relevant for farms and peasants—the private sector of greenhouse production.

2 Materials and Methods

When conducting an analytical review of the development prospects of the domestic protected ground and modern technologies currently used in real production and recommended for the implementation, the following methods were used: economic-statistical, methods of system and comparative analysis, and mathematical modeling and planning [1, 5]. The study is based on the collection and analysis of information and statistical data of RosGosstat, the international organization FAO (The Food and Agricultural Organization of the UN), which owns reliable information in the field of world production of various types of food, the Republican Production and

Scientific Association "Greenhouses of Russia," and the assessment of the development trends of world greenhouses and the state of the domestic greenhouse industry. The study was carried out in three stages: (1) an analytical review of the volume of world production of products in greenhouses and an assessment of the pace of its development over the past 20–25 years; (2) the assessment of the state of the Russian protected ground industry; (3) the recommendations for the implementation of the most effective technologies, equipment, and organizational and technological production systems.

3 Results and Discussion

The study was conducted in three stages. In the first stage, the global production of greenhouse products was analyzed. Glasshouse horticulture is a promising type of business in agriculture globally. More than 100 countries, the most developed economically and politically, grow crops in greenhouses and have a decisive influence on the food balance of the planet. The area of protected ground under production of vegetable crops has increased over the past 10 years by more than 40% to about 2.7 million ha. World greenhouse facilities produce more than 30 million tons of various types of products. The structure of the areas and the cultivation facilities is diverse. The countries located in the northern part of Europe give preference to the use of glass year-round greenhouses; in more southern countries, the preference is given to light structures or even film shelters (Table 1).

The greenhouse sector of agriculture is growing in popularity around the world. The global market for protected ground is expected to grow by 10–11% per year during 2017–2021. At the same time, Europe, the Middle East, and Africa will become the most promising regions for protected horticulture. Large-scale construction of new-generation greenhouses is expected in Asia. China remains the leading player

Table 1 The protected soil areas in different countries of the world

Country	Area (ha)	Population (million)
Spain	52,000	40.6
Japan	42,000	126.5
Turkey	41,000	78.8
Italy	20,000	61.0
Netherlands	10,000	16.8
Morocco	10,000	32.0
France	8500	65.3
Poland	6300	38.4
Russia	2600	143.0
China	25,00,000	1336.7

in this process, already having more than 2.5 million ha of protected ground, and now focused on new technologies and facilities with controlled microclimate.

The greenhouse industry in Russia reached its maximum development point in the 80s of the twentieth century. During this period, the profitability of greenhouses was up to 70–200%, which provided industry enterprises with stability and the opportunity to develop further. The total area of industrial winter glass greenhouses at that time was more than 4.7 thousand ha. Crop yield of greenhouse soil on average did not exceed 20–25 kg/m^2 per year. However, on some advanced farms, yields of 40–50 kg/m^2 have already been achieved. This marked the beginning of the use of photoculture. The greenhouse complexes were distributed relatively evenly in Russian territory. Almost all areas, including the most northern, Karelia, Chukotka, and Taimyr, had their production of off-season products. Most industrial greenhouses were in the Moscow region, and their total area reached 450 ha.

In Soviet times, Russian scholars developed technological methods and equipment for greenhouses, but now, the knowledge comes to Russia from Israel and the Netherlands.

During the Perestroika period, a significant part of the areas of closed ground fell into decay. The cessation of the usual subsidies, the breakdown of interregional ties, hyperinflation, a drop in the standard of living, and a sharp jump in the growth of energy tariffs led to the cessation of many greenhouse plants, both in Russia and in the neighboring CIS countries. The volumes of greenhouse production had been declining almost until the end of the last century. In 1996, the lowest gross harvest of domestic greenhouses was recorded at the level of 459 thousand tons. In the same period, the mass transfer of greenhouses from state ownership to private began. Most greenhouse farms could not upgrade or modernize the fixed assets that had exhausted their resources. In total, during the years of Perestroika, Russia lost about 50% of its protected ground. The only greenhouses that have survived are those that operate on gas (its use is about three times cheaper than using other energy carriers) or have incentives for full or partial (up to 50%) compensation of energy costs with the support of the regional authorities.

By the beginning of the new century, the greenhouse industry in Russia came up with less than two thousand hectares of covered ground, 60–80% of which were already mentally and physically worn out [3].

In Russia, there are 2.6 thousand ha of winter greenhouses and 3–5 thousand ha of film greenhouses. This is a drop in the ocean. The highest greenhouse production is outside Russia, in the West (up to 200 thousand ha), the Middle East (up to 280 thousand ha), and other regions of the world. In Russia, there are 1.3 m^2 of greenhouse area per resident (in Poland—16.4, China—15.0, France—13.0, Spain—12.8, The Netherlands—6.0 m^2). Today, each region has adopted programs for the development of the protected soil. Private businesses invest in the construction of greenhouses; there is also support from the state. Today, 250 ha of new generation greenhouses are put into operation in Russia every year. According to the Greenhouses of Russia Association, the pace of constructing greenhouses in comparison with 2013 (before the embargo on greenhouse products) has doubled. During 2014–2018, about 1000 ha of new modern high-tech complexes were built and put into operation (Table 2).

Table 2 Gross harvest and yield of vegetable crops in the greenhouses of Russia (2014–2018)

Years	Gross harvest (thousand tons)	Productivity (kg/m^2)
2014	690.8	29.6
2015	709.8	31.8
2016	818.6	34.3
2017	922.2	36.9
2018	1067.4	40.2

Table 3 The structure of the vegetables, produced in greenhouses by years (%)

Indicators	2014	2015	2016	2017	2018
Cucumber	60.9	58.5	66.8	69.6	69.8
Tomato	36.5	29.3	27.6	26.0	27.6
Pepper	0.4	0.4	0.3	0.4	0.4
Eggplant	0.5	0.5	0.6	0.5	0.6
Green	2.9	3.2	3.3	3.5	3.7
	100.0	100.0	100.0	100.0	100.0

There is a natural annual growth in production and an increase in the yield of vegetables from the protected soil. Unfortunately, out of 70 types of vegetable crops in Russia, just over 25–30 are still grown (Table 3).

The main crops in the production's structure in the protected ground of Russia are cucumbers (up to 70%) and tomatoes (up to 28%).

4 Conclusion

The analysis of the situation in the protected soil industry shows that the potential for the development of greenhouse horticulture is great [6]. The sector of the greenhouse production in Russia, having survived the crisis of the 90s, began to recover. This was facilitated by the measures of state support provided in the State Program of Industry Development.

Large domestic firms and companies (PCF "Agrotip," RPC "Fito," LLC "Reflaks," LLC "Agrisovgaz," and others) that offer the latest designs and equipment of innovative and energy-saving technologies successfully operate in Russia's greenhouse market. Many agro-industrial holdings are planning the construction of new greenhouse complexes ranging from 40–100 ha in the central part of Russia, in the southern regions, and beyond the Urals. According to the targets of the State Program, by 2020, the area of winter greenhouses should be increased to 4.7 thousand ha. To achieve this indicator, it is necessary to produce about 800 thousand additional tons of vegetables, which will require the construction of 1600 ha of greenhouses with an average yield of 50 kg/m^2. The result of these measures will be reaching 100% coverage of the country's domestic market in the production of cucumber and 70–80% in the production of tomato.

References

1. Behrens, W.: Guidelines for the preparation of industrial feasibility studies. CJSC Interekspert, Moscow, Russia (1995)
2. Detkov, N.S.: Modern technologies for growing vegetable and flower crops in greenhouses. Light culture. Greenhouses of Russ **1**, 16–20 (2018)
3. Litvinov, S.S., Nurmetov, R.J., Alekseeva, K.L., Selivanov V.G.: Constructions, Technologies, and Technical Means for the Production of Vegetable Products in Greenhouses. Guidelines. Listerra Publishing , Moscow, Russia (2015)
4. Nechaev, V.I., Saifetdinova, N.R., Bogoviz, A.V.: Theoretical aspects of state regulation of agriculture within the classical and physiocratic schools: a modern view. Adv. Intell. Syst. Comput. **726**, 870–884 (2019)
5. Razin, A.F.: Modeling innovative production of competitive products. Bull. Moscow Acad. Labor Market Inf. Technol. **11**, 108–115 (2004)
6. Razin, A.F., Meshcheryakova, R.A., Tektarova, S.V., Telegin, G.A.: The analysis of the state of economic efficiency of vegetable growing in the Russian Federation. Agro-Ind. Technol. Central Russ. **1**(7), 68–75 (2018)

Promising Directions for the Use of Land Resources of Russia in Agricultural Production

Gennadiy A. Polunin, Valeriy V. Alakoz, and Kirill I. Chekrahsin

Abstract In Russia, there is a significant problem of abandoned agricultural land—a quarter of old arable land is not used. If compared to 1990, the area of fodder land, together with an almost twofold reduction in the number of cattle, has underwent the most significant reduction. The authors of the paper raise the question of the causes of this phenomenon, discuss the possibilities of returning lands to circulation, and define the priority areas for using these lands. This negative process is most evident in those areas with adverse agro-climatic conditions. In the south of the country, in the Central Black Earth Zone, there was no noticeable decline in production. In contrast, there is a stable growth in the agro-industrial sector nowdats. Considering the issue of demand for agricultural products (one of the primary sources of demand for agricultural land), we can establish that the population's need for crop production is satisfied. The expansion of sown areas makes sense only for the production of a fodder base for the development of meat and dairy farming, where Russia has not yet provided the level of production necessary to fully meet the needs of the population. From the point of view of supply and demand on the land directly, there are also several problems impeding the involvement of land in circulation. The lack of a developed civilized land market and the predominance of shared ownership of land artificially reduce the supply of land. The solution of the described problems, taking into account the significant land potential of Russia, will make it possible to adequately fill the demand for meat and dairy cattle breeding to ensure the growth of the exports of crop production and the development of the agricultural sector as a whole.

G. A. Polunin (✉) · V. V. Alakoz · K. I. Chekrahsin
Federal Research Center of Agrarian Economy and Social Development of Rural Areas, All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: polunin.zem@vniiesh.ru

V. V. Alakoz
e-mail: alakoz.zem@vniiesh.ru

K. I. Chekrahsin
e-mail: cherkashin.zem@vniiesh.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_58

Keywords Use of agricultural land · Land policy · Unused land · Food security of the Russian Federation

1 Introduction

Considerable differences in climate and soil determine the natural conditions of the Russian agricultural zone. In the predominant part of this zone, there is a continental climate that is characterized by significant temperature differences. In the latitudinal direction, the atmospheric humidification, the duration of the growing season, and the heat stress are changing. In the northern part of the zone, with sufficient atmospheric and soil moisture, the limiting factors for agriculture include a low heat supply and a short growing season; in the southern part, there is a lack of moisture. The climatic conditions of the North Caucasus, except the eastern part, and the Central Black Earth Economic Region, are close to optimal values. Potential soil fertility in the European part of Russia increases from north to south, reaching a local maximum in the Central Black Earth Region. Further south and southeast, it decreases and rises again in the North Caucasus, reaching a maximum in the Krasnodar Territory. More than 70% of the agricultural territory of Russia is characterized by an extremely cold and arid climate and low biological activity. The bioclimatic potential of the agricultural territory of Russia is 2.4–3.2 times lower than in the countries of Western Europe and the USA [6].

Despite the deceptive impression its vast state, Russia has 123.1 million hectares of arable land, putting it in third place behind India (156.5 million ha.) and the United States (152.3 million ha.) according to FAO estimates [2]. China is in fourth place (119.0 million ha.). By the area of arable land per inhabitant, Russia is in fifth place with an indicator of 0.85 ha. after Australia (1.93 ha.), Kazakhstan (1.68 ha.), Canada (1.22 ha.), and Argentina (0.90 ha.).

According to the statistics, the acreage of crops over the last century had the dynamics on the territory of modern Russia [14] as follows: From the time of the decline of the Russian Empire until the second half of the twentieth century (except the period of World War II), there was a continuous development of land for crops. The maximum acreage occurred in the period between 1980 and 1985 (124.8 million ha.). In the late 1980s, a decline began, and it continued until 2007 when the sown area reached its minimum (74.8 million ha.). In the last ten years, the abandoned land has gradually been returned to circulation. As of January 1, 2018, the cultivated area amounted to 80.6 million ha., below the level of 1930. The area of old arable lands retired from circulation (compared to 1985) reached 44.2 million hectares.

This trend is typical for Russia; things are different elsewhere in the world (Table 1; [11]). According to the UN Food and Agriculture Organization [2], among the leading countries in terms of arable land, against the background of a moderate decrease in the area of arable land, the Russian Federation turned to be the only state where the harvested area for the period 1992–2015 has been reduced (Fig. 1).

Table 1 The dynamics of the use of arable land among the countries of leaders in arable land

Country	Arable land, million ha			Grain sown areas, million ha			Harvested crops, million ha		
	1992	2015	+/− in %	1992	2015	+/− in %	1992	2015	+/− in %
India	162.7	156.5	−3.8	99.5	99.5	+0.0	198.6	203.3	+2.4
USA	184.1	152.3	−17.3	65.9	58.1	−11.8	138.2	141.2	+2.1
Russia	132.0	123.1	−6.7	59.5	42.8	−28.1	105.5	77.5	−26.5
China	122.9	119.0	−3.2	92.1	95.6	+3.9	169.5	202.2	+19.3
Brazil	51.8	80.0	+54.5	20.6	21.2	+3.1	56.2	77.1	+37.2
Australia	47.2	46.1	−2.3	13.3	18.4	+37.8	20.8	27.7	+33.5
Canada	45.6	43.6	−4.3	20.2	14.6	−27.7	31.7	34.3	+8.3
Argentina	26.8	39.2	+46.4	8.7	11.1	+28.3	22.0	43.2	+96.2

Source Developed by the authors based on the statistics [2]

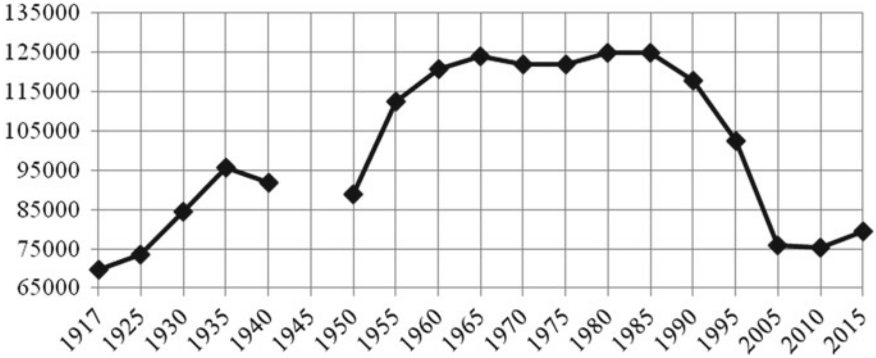

Fig. 1 The dynamics of acreage in farms of all categories on the territory of the Russian Federation, thousand hectares. *Source* Developed by the authors according to the Rosstat data [14]

In order to avoid the further development of this negative process for Russia with its agroclimatic and historical prevailing diversity of agricultural land, it is essential to pay attention to the development and maintenance of land policy both at the state level and at the regional level, taking into account local climatic, economic, social, and environmental features, traditional land ownership and use of systems for the regions.

2 Materials and Method

In order to develop land policy, a comprehensive analysis of the existing problems associated with the use of land in the process of agricultural production is necessary. The information base of the study was departmental statistical data of the Unified Interdepartmental Information and Statistical System [14], reports of the Federal Service for State Registration, Cadastre and Cartography, and data on tenders for the rental and sale of land [13].

The task of the study is to identify negative trends, group the constituent entities of the Russian Federation according to the degree of manifestation of these trends, and determine and evaluate the most promising directions for the development of agricultural land use in these regions.

The key issue addressed in the study is the possibility of involving the unused lands in circulation in order to expand production. This problem is considered both from the point of view of supply and demand for agricultural products and from the supply and demand for the land plots themselves. The state of the land market is investigated.

3 Results

3.1 Non-use of Land

The most considerable reduction (Table 2) was in the area of forage crops. The peak in the area occupied by forage crops occurred in the period 1985–1993. Then, crops decreased from 44.6 million hectares in 1990 to 16.4 million hectares in 2016 (63.2%), which is associated with a reduction in the number of cattle from 57 million animals in 1990 million animals to 18.8 million animals in 2016 (67.0%), including cows from 20.6 million animals to 8.3 million animals (59.7%), as well as sheep and goats from 58.2 million to 24.8 million (57.4%) and pigs from 38.3 million to 22.0 million (42.6%).

The main factors determining the conditions for the non-return of old arable land into circulation remain the low profitability of agricultural production in the territories with unfavorable agro-climatic conditions and insufficient state support for the producers.

We can distinguish two groups of subjects in which marked negative processes manifest themselves to a greater extent.

The depressed regions are the Arkhangelsk, Pskov, Kostroma, Kirov, Yaroslavl, Vologda, Vladimir, and Smolensk regions; the republics of Karelia, Buryatia, and Mari El; and the Perm and Trans-Baikal territories. In these regions, there is a high proportion of unused old arable land (more than 40%) and a pronounced tendency to retire from agricultural circulation. The situation is aggravated by the unfavorable demographic situation. In most regions, over a period of 10 years, the rural population decreased 15–20%, the working-age population decreased 25–35%, and the proportion of abandoned settlements increased from 15 to 35% [1].

The areas with relatively favorable agro-climatic conditions in which there is a large share of unused valuable land include Ulyanovsk, Penza, Ryazan, and Tula, as well as the Republic of Mordovia. In these regions, the share of unused old arable land exceeds 20% of their total area. Moreover, most of the soil cover is occupied by fertile black earth and gray forest soils. This group can be considered the most promising for increasing the country's agricultural production.

Despite unfavorable agro-climatic conditions, there are definite trends in some regions: the Chechen Republic, the Republic of Ingushetia, the Dagestan, North Ossetia-Alania, Primorsky Territory, the Kaliningrad, Kurgan, Bryansk, Amur, and Jewish Autonomous Regions.

In these areas, a relatively low share of the unused arable land is observed, and, over the past ten years, the area of the used arable land has increased by an average of 20%. The geographic location of the regions, favorable for economic development (access to markets, availability of labor resources), as well as the implementation of investment projects, including state participation, made it possible to develop the industry in the regions of this group.

Table 2 The area of agricultural land and crops in all categories of lands (thousand ha)

Year	Agricultural grounds	Arable land	Arable land in the category of agricultural land destination	Hayfields and pastures	Layland	Fallow land	Total sown area
1	2	3	4	5	6	7	8
1985	218400.0	133900.0	н/д	83100.0	–	14500.0	119121.0
1990	222409.2	132304.2		87899.5	347.2	13808.0	117705.2
1995	221985.2	130197.6		88229.2	1456.4	17383.0	102540.5
2000	221088.8	124373.8	115472.7	90923.4	3927.2	16934.8	84669.6
2005	220679.0	121780.9	115266.8	92098.8	4998.9	13859.4	75837.0
2010	220396.3	121433.9	115136.5	92059.5	5103.3	13919.1	75187.9
2015	222066.3	122752.6	116271.4	92501.9	4910.9	11937.8	79319.0

Year	Cereals and legumes	Forage crops	Sown areas of agricultural enterprises	Sown areas of the peasant farm	Sown areas of households	The unused old arable land	
1	9	10	11	12	13	14	15
1985	68138.0	40830.0	116821.0	–	2300.0	–	
1990	63067.8	44560.4	117695.2	10.0	2407.5	1138.2	0.90%
1995	54705.2	37056.4	93044.6	5061.1	4434.8	11730.5	8.90%
2000	45585.4	28898.5	74191.9	6500.8	3977.0	26696.6	20.80%
2005	43593.4	21609.6	60471.5	11942.6	3422.9	37083.4	29.30%
2010	43194.2	18071.1	56104.3	15601.1	3482.5	37430.2	29.60%
2015	46642.5	16974.0	55099.3	20799.7	3420.0	36406.8	28.50%

Note Graph 14 = Graph 3 + Graph 6 − Graph 7 − Graph 8; Graph 15 = [Graph 14/(Graph 3 + Graph 6)]*100
Source Developed by the authors according to the Rosstat data [14]

3.2 *The Production and Consumption of Agricultural Products*

For most agricultural products, Russia provides its own necessary raw materials for food production (Table 3). The most considerable lag exists in the production of dairy products and vegetables. Dairy products are consumed at only 72.6% of the recommended norm. Only 81.2% of the total milk consumed is of domestic production. The consumption of vegetables and cucurbits is 20% behind the norm, but almost all of the consumed products in this category are of domestic production (94.6%).

For the production of vegetable crops, it is optimal to use greenhouse complexes that do not require the use of large areas. For milk production, it is necessary to grow fodder crops.

According to the calculations made by Polunin et al. [8, 9], in order to provide feed for an additional livestock of dairy cows with a full cycle of its reproduction, providing the country's population with milk and dairy products according to the standards of a healthy diet recommended by the Russian Federation's Ministry of

Table 3 The consumption of basic foodstuffs by the population of the Russian Federation as of January 1, 2017

Food	Consumed in 2016, kg/year/person	The level of self-sufficiency in actual consumption, %	Recommended for consumption, kg/year/person	The level of self-sufficiency in recommended consumption, %
Meat and meat products calculated as meat	74	90.7	73	91.9
Milk and dairy products calculated as milk	236	81.2	325	58.7
Eggs and egg products (pieces)	273	98.6	260	104.5
Potatoes	113	97.3	90	157.9
Vegetables and cucurbits	112	94.6	140	76.4
Bread products (bread and pasta calculated as flour, flour itself, cereals, and legumes)	117	–	96	–

Source Compiled by the authors according to the Rosstat data [14]

Health with the current level of agricultural technology, it will be necessary to return 70% of previously abandoned arable land to economic turnover. At the same time, the production of cattle meat, which is currently lacking in the population's diet, will increase.

With the use of more productive breeds of dairy cattle, the use of the nutritionally balanced feeds, and the introduction of modern animal husbandry technologies, then the cultivation of feed crops and feed production, the need for cows, and productive agricultural land for fodder production can be reduced by half [including the subjects with favorable agro-climatic conditions, with an increase of no more than 12% (the Belgorod region—6.9%, Voronezh—9.0%, Kursk—7.4%, Lipetsk—9.1%, Tambov—11.5%, Krasnodar—3.5%, Rostov—9.0%, Stavropol—6.8%, the Republic of Adygea—9.4%, the Republic of North Ossetia-Alania—11.1%, the Kabardino-Balkarian Republic—9.0%, the Republic of Tatarstan—7.7%, the Altai territory—12.2%, the Jewish autonomous region—1.3%)]. Since the available land potential is already almost entirely involved in agriculture, it is impossible to increase agricultural production without attracting investment and intensifying production.

The full utilization of all available land potential (sown areas of 1990) can be increased by 30% by involving all old arable lands in circulation while maintaining the current ratio of crop and livestock sectors, the structure of sown areas, and the level of management (achieved crop yields and productivity of farm animals as well as management quality), taking into account the introduction of previously less fertile lands withdrawn from plowing.

In the constituent entities of the Russian Federation, located far from large regions where agricultural products are sold (with expensive transport accessibility, low bioclimatic potential, and solvent consumer demand), the agricultural production can be increased by 2–3 times and more due to the expansion of sown areas on old arable lands removed from the service (the Kaluga, Kostroma, Smolensk, Tver, Yaroslavl, Novgorod, Pskov, Kirov, and Irkutsk regions and the Zabaikalye Territory). Nevertheless, for their reasonable involvement in economic activities, the measures of state support that are aimed at increasing the sufficient demand of the local population for food, creating jobs in rural areas, and supporting the profitability of agricultural production are needed.

3.3 Land Ownership in Modern Russia

According to Rosreestr, as of January 1, 2017 [7], of all the lands of Russia in private ownership (133.2 million hectares), agricultural lands accounted for 96.1% (128.0 million hectares), of which 67.3% (86.1 million ha) were land shares of citizens in total land ownership.

A significant part of the agricultural land is in state and municipal ownership: 255.6 million hectares (66.6%); in the ownership of citizens: 109.7 million hectares (28.6%); in the ownership of legal entities: 18.2 million hectares (4.8%). Over the past ten years, the share of land in state and municipal ownership has decreased by only 2%. The agricultural organizations received 75.1 million hectares of arable land and farms, individual entrepreneurs received 18.8 million hectares, and citizens received 22.9 million hectares.

The process of allocation of land plots at the expense of land shares unreasonably dragged on. The number of land plots owned as of the beginning of 2017 is 1,559,647 on an area of 53.7 million ha. (on average, 34 ha per plot), of which the state real estate cadaster has information about the location of the boundaries of shared plots of land of 1,120,706 (71.8%) plots with a total area of 30.5 million ha (56.8%). There are no data on the location of the borders of 438,941 land plots (28.1%) on an area of 23.2 million ha (43.2%) in the shared ownership.

The number of land shares included in the unclaimed lists is 1,776,749 on an area of 18.5 million hectares (an average of 10 hectares per share), of which only 590,388 (33.2%) on an area of 5.5 million hectares were recognized as municipal property by the court (29.7%).

According to the statistics [12], at the beginning of 2018, information on 59.5 million land plots was included in the state register, of which only half (31.1 million) have borders established in accordance with the requirements of the law.

The slowing down of the process of converting land shares into a land plot was affected by the vesting of participants in the land share with significant rights that landowners have.

According to the provisions of the Land Code of the Russian Federation [3], a participant in the shared ownership is entitled to, at their discretion:

- bequeath the land share;
- abandon the ownership of the land share;
- contribute the land share to the authorized (joint-stock) capital of an agricultural organization using a land plot in the shared ownership;
- transfer the land share to trust;
- sell or present the land share to another participant in the shared ownership;
- sell or present a land share to an agricultural organization or a citizen—a member of a peasant (farmer) farm using the land plot in the shared ownership.

If a participant in the shared ownership decided to allocate a life-size land plot, then the procedure is carried out on the basis of a draft land survey approved by the decision of the general meeting of the participants in the shared ownership, or by the decision of the owner of the land share or land shares.

In the past few years, local authorities have joined the transformation of land shares into land plots, which provide legal assistance to the participants in the land shares and seek the right of ownership of the unclaimed land shares in court. However, the modest budget of municipalities and the length of court cases do not allow for solving this problem as a whole in the next five to six years.

3.4 The Market of Agricultural Land

The land market is developing primarily through the leasing and sale of land owned by state and municipal property. According to the information portal torgi.gov.ru [13], out of 85 constituent entities of the Russian Federation, only 40 or 45% of the total number of transactions with land plots is actively completed. Moreover, the preference is given to the rental of land in relation to its alienation. If we evaluate the market capacity of state and municipal lands, then it is measured by several hundred thousand hectares per year.

The analysis of the results of public tenders on the farmland rental in 2016–2017 showed that in eight constituent entities of the Russian Federation, included in the Southern and North-Caucasian Federal Districts, renting a land plot brings its owner at least ₽ 3,000 a year per 1 ha. This level was reached by the Krasnodar Territory, Belgorod Oblast, Kursk Oblast, the Stavropol Territory, Rostov Oblast, the Republic of Dagestan, and the Kabardino-Balkarian Republic. The Krasnodar Territory remains the undisputed leader in this indicator, as its value has reached 12,000 ₽/ha on individual land plots.

Meanwhile, up to 3,000 ₽/ha has been obtained in the Oryol, Bryansk, Volgograd, Ryazan, Tambov, Lipetsk, and Voronezh regions. At the same time, the lower border of the rent is not stable, which did not allow us to establish its value unambiguously.

Most constituent entities of the Russian Federation today receive less than 1000 ₽/ha or $17. There are more than eighteen.

In several Russian regions, the rent of farmland brings a symbolic income to its owner in an amount not exceeding 300 ₽/ha. This is the Kirov, Irkutsk, Magadan, Murmansk, and Arkhangelsk regions, the Republic of Tuva, and the Republic of Komi.

The number of transactions for the sale of land is insignificant and does not allow for the characterization of the market value of agricultural land. According to expert estimates, the average market value of land, for example, in the Penza, Voronezh, Lipetsk, and Saratov regions is estimated at ₽ 20 thousand, 50 thousand, 40 thousand, and 15 thousand per ha, respectively, and in the Stavropol Territory, ₽ 100 thousand.

4 Discussion

Russia has set one of the primary tasks of land policy to return most of the arable land to agricultural production. To solve this problem, the system of state control and municipal oversight of the use of agricultural land is continually being improved. More stringent requirements for the land users are introduced at the legislative level for the non-use or the improper use of agricultural land, up to their forcible withdrawal by court decision, and transfer to municipal ownership with subsequent handing over for rent or sale in electronic bidding.

However, the use of coercive measures alone is not enough. Therefore, the government plans to increase domestic and foreign demand for agricultural products in the next six years. On the one hand, due to a steady increase in real incomes of citizens, there has been an increase in the level of pension provision above inflation and the halving of poverty. On the other hand, parties bring the export of agricultural products from $25 to $45 billion by 2024 [11].

In addition to expanding the production and export of traditional agricultural products (grain, vegetable oil, and sugar), Russian business plans to develop the production and export of meat and dairy products.

Beef and dairy cattle breeding is considered the most promising direction for the development of the use of agricultural land, since, in addition to promoting the subindustry for export, domestic consumption is much lower than rational food standards and does not reach the level of self-sufficiency in meat and milk that was established by the indicators of the country's Food Security Doctrine [10].

The expansion of livestock production should serve as a driver for restoring the viability of rural areas in the non-black earth zone, which accounts for most of the unused land. The creation of profitable jobs is a key factor in the development, and in this regard, livestock raising is the largest industry by the labor costs. For other agricultural lands, a land-use conservation program should be developed.

The Land Code of the Russian Federation establishes the priority of protecting the land as the most important means of agricultural production, over its use for other purposes. Particularly valuable productive agricultural land, listed in the legislation of the constituent entities of the Russian Federation, cannot be used for other purposes. Separate constituent entities of the Russian Federation, Moscow, and the Moscow Region, have established an economic mechanism to protect agricultural land from being used as real estate, introducing a fee "for building rights" and it is advisable to extend this experience to all other regions of the country [4, 5].

5 Conclusion

Russia possesses sufficient land potential and labor resources for increasing agricultural production in the next six years. The achievement of this goal seems possible, on the one hand, by involving the unused agricultural land in production activities, and on the other, by gradual technical and technological re-equipment of production, as is quite successfully done today, by providing subsidies to businesses through state and regional rural support programs. The implementation of this strategy will allow Russia not only to provide the local population with food fully but also to supply a significant portion of food products to the world market.

References

1. All-Russian Census—2010: Volume 1, Population and distribution. Retrieved from https://www.gks.ru/free_doc/new_site/perepis2010/croc/perepis_itogi1612.html (2013)
2. FAOSTAT: Official statistics. Retrieved from https://www.fao.org/faostat/en/ (2019)
3. Federal Assembly of the Russian Federation: Land code of the Russian Federation (October 25, 2001, No. 136-FZ). Moscow, Russia (2001)
4. Government of Moscow: Order No. 593-PP of September 10, 2013. Moscow, Russia (2013a)
5. Government of Moscow: Order No. 1190/57 of December 31, 2013. Moscow, Russia (2013b)
6. Ministry of Agriculture of the Russian Federation: Guidelines for the comprehensive monitoring of soil fertility of agricultural lands (April 9, 2003, No. 8). Moscow, Russia (2003)
7. Ministry of Economic Development of the Russian Federation: State (National) Report on the State and Use of Land in the Russian Federation in 2016. Rosreestr, Moscow, Russia (2017)
8. Polunin, G.A., Alakoz, V.V., Cherkashin, K.I.: The unused land potential of Russia and the possibility of food security. AIC: Econ. Manag. **6**, 4–16 (2018)
9. Polunin, G.A., Alakoz, V.V., Nosov, S.I., Bondarev, B.E., Ogleznev, A.K., Cherkashin, K.I.: Particularly valuable agricultural land in the European part of the Russian Federation. Mechanisms for the regulation of intersectoral redistribution of agricultural land. Land Manag. Cadaster Land Monit. **5**, 16–27 (2018)
10. President of the Russian Federation: Order on approving the doctrine of food security of the Russian Federation (January 30, 2010, No. 120). Moscow, Russia (2010)
11. Presidium of the Presidential Council for Strategic Development and National Projects: Passport of the national project (program) "International Cooperation and Export" (December 24, 2018, No. 16). Moscow, Russia (2018)
12. Rosreestr: Statistics. Retrieved from https://rosreestr.ru/site/open-service/statistika-i-analitika/statisticheskaya-otchetnost/ (2019)
13. The Official Website of the Russian Federation for Posting Information on Bidding: Lease and sale of land. Retrieved from https://torgi.gov.ru/lotSearch1.html?bidKindId=2 (2019)
14. UIISS: Official statistics. Retrieved from https://www.fedstat.ru/ (2019)

Breeding Horse Auctions as an Important Link in the Horse-Breeding Business

V. S. Koveshnikov, A. N. Pobedinskiy, and E. V. Slotina

Abstract The main objective of the study is to study in the interval time aspects capturing the dynamics of the effective sale indicators of the young trotter breeds at fifteen auctions in the Moscow farm No. 1. The organizational forms of selling the breeding horses of factory breeds during the planned economy and over the years of market relations are also studied. The experience of intra-industrial labor division in horse breeding of highly developed foreign countries is analyzed. The role of auctions in the sale of breeding young animals, which are an effective and determining link in the system of intra-division of labor, is economically justified. Using the method of comparative economic analysis over the fifteen years of the functioning of the auction, the primary production and economic indicators for the selling of year-old Oryol and Russian trotter breeds are analyzed. The authors scientifically substantiate conclusions on the activation and increase of the efficiency of the domestic market of pedigree horses through the organization and functioning of ongoing auctions. Considerable economic advantages of the auction sale of horse breeding in comparison with the sales in a usual way are established.

Keywords Pedigree horse breeding · Breeds · Sales · Auctions · Foreign and domestic experience · Economic efficiency

1 Introduction

The objective transformations in the horse breeding industry during the period of market reforms are determined by the general trends of the economic situation in Russia. The comprehensive processes of privatization, with a significant decrease in the number of large agricultural enterprises, were accompanied by the process of the

V. S. Koveshnikov · A. N. Pobedinskiy
All-Russian Research Institute of Horse Breeding, Divovo, Russia
e-mail: v5695096@yandex.ru

E. V. Slotina (✉)
Ryazan State Medical University Named After Academician I. P. Pavlov, Ryazan, Russia
e-mail: e-slotina@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_59

steady dumping of horse stock and the shift of the horse breeding industry to the eastern regions of the country at the first stage of market reforms. Unfortunately, the breeding of pedigree horses, being a pivotal sub-sector, has not fully adapted to the new challenges of our time. Reduced development and the limited domestic market of pedigree horses; the absence in the intra-industry division of labor in such important segments as the national equestrian totalizer, training centers, and auctions; and an outdated material and technical base led to a significant decrease in the quality of pedigree products and an increase in the unprofitableness of the industry. The objective of the research was to study the dynamics of the main production and economic indicators of selling young trotter animals under the age of 1.5 years at the auctions in the Moscow Stud Farm No. 1 for 2014–2018. In order to identify the reserves of the effectiveness of pedigree horse breeding, an in-depth analytical review of the experimental material was carried out with an assessment of two methods of selling young trotter breeds in the usual manner and at the auctions.

2 Materials and Methods

The research materials were data from the centralized pedigree research of the Russian Research Institute of Horse Breeding, annual catalogs of horses put up for sale, working records of auction results, individual information sources on the results of horse trade abroad, and the materials of annual statistical reporting on trotting studs.

During the research, such generally accepted methods of economic analysis as comparison, grouping, and factorial analyses were used.

3 Result

Pedigree horse breeding is considered to be the “heavy industry” of the horse breeding industry. It supplies horses for the improvement of working, meat, herd, and dairy directions, as well as for classic and mass equestrian sports, tourism, rental, hippotherapy, etc. In a planned economy, the development of the industry was determined by the need for mass horse breeding, primarily working and productive, and pedigree breeding of horses of different pedigree directions. In the pre-reform period, the economic basis for the development of the industry was determined by the proceeds from the sale of pedigree horses. If it is impossible to ensure the self-sufficient development of the industry, the losses of horse farms and pedigree farms are compensated by the development income of the so-called “additional,” but more profitable livestock and crop production sectors. The selling of pedigree horses in bulk was carried out by the organizations of the system of pedigree associations in a planned manner at current prices.

Under market conditions, domestic pedigree horse breeding and, above all, horse breeding, found themselves in a difficult economic situation. During the period of market relations (1991–2018), mainly negative trends of a technological, organizational, and economic nature, took place in pedigree horse breeding.

Among the technological shortcomings, it is necessary, first of all, to highlight a decrease in the level of reproduction of horses, which limits the marketability of the industry, leads to a significant increase in the cost of pedigree products, and creates difficulties in equipping racetrack. So, in Russian breeding studs, per 100 mares, the business yield of foals decreased from 72–75 to 52–57 animals, and the sale of pedigree horses from 40–45 to 28–30 [3].

The allocation of costs for the maintenance of the breeding stock, to a large extent, determines the cost of foals for weaning and their subsequent rearing to any age. It was found, at the Prilepsky stud farm, that the cost of a foal at birth and a forty percent yield was ₽ 35 thousand, while at the Omsk stud farm, which received 70 foals per 100 mares, this indicator amounted to ₽ 10.1 thousand [7].

The main organizational and economic reasons for a negative nature include the lack of an intrasectoral division of labor at different stages of obtaining, raising, and selling pedigree horses.

V. A. Bochkarev identifies four production units at different technological stages of pedigree horse breeding in the USA:

- pedigree horse farms (in Russia, these are horse factories and reproducers), where horses are born and raised, mainly until they are one year old (weaning, handling, and stopping of young animals);
- year-old auctions where young horses aged 12–18 months are sold between September and November;
- training centers and private individuals preparing horses for a prize-winning career, amateur riding, rental, and other purposes; and
- racetracks, testing trotting horses of various ranks and purposes [1]. As a result, breeding farms abroad are freed from the costly overexposure of young horses, which are sold at the age of one to one-and-a-half years at the auctions.

The organizational shortcomings of domestic pedigree horse breeding include the lack of the above intra-industry specialization. The young animals are reared in reproductive farms (stud farms, pedigree reproducers, and individual owners) up to the age of 2–2.5 years, then they are transferred to farmers for testing and remain their property until they are sold. At the same time, most of these farms, due to personnel shortage and lack of a modern production base for factory and sports training of young animals, cannot objectively prepare high-quality horses for a prize or sports career [6].

In the rational organizational and technological chain that has developed in the horse breeding of foreign countries, a stud farm–auction–training center–racetrack (sports arena), the missing links in our country are auctions and training centers.

In the pre-reform period, even though the bulk of pedigree horses was sold centrally, through a system of regional tribal associations, the practice of auctioning pedigree horses proved to be very good. There were auctions of trotters in the Moscow and Perm stud farms and Arabian horses in the Tersk stud farm [9].

The studies conducted by scholars and practitioners on the accelerated sports training for 2.0–2.5-year-old young Don and Budyon breeds in the stud farms, which were named after S. M. Budenny and the 1st Horse Army, with the subsequent implementation of prepared horses on factory auctions are of particular interest. As a result, due to higher prices at auctions and a reduction in the growth of young stock by 5–7 months, the profitability from the sale of prepared young stock increased in the Budyon breed from 68.7 to 206.3% and in the Don breed from 42.5 to 173.1%. Between 1981 and 1990, in order to introduce, prepare, and implement new technology, 19 auctions were held, at which 1,100 horses were sold for a total of ₽ 8.9 million. Additional profit amounted to ₽ 3.0 million, which is 33.7% higher than the base indicator [6].

Under market relations, the production composition of breeding horses of all factory breeds was deconcentrated. Among the breeding enterprises, the first place is occupied by individual owners, having 4,270 mares and 830 stallions, which makes up 46.8 and 62.2% of their total number in the horse-production stock, respectively. Per the owner, there are four mares and less than one stallion (0.7). At the same time, there was a significant decrease in the product composition in stud farms, where the best horses of the pedigree core are kept. Under such conditions, as the experience of countries with developed horse breeding shows, auctions should become the main organizational form for the sale of pedigree horses [2, 4].

In this regard, we have analyzed the experience of the operation of the international auction of pedigree horses in the Moscow stud farm No. 1. The stud farm is located in the Odintsovo district of the Moscow region. It is the leading farm for breeding pedigree horses of the Oryol trotter breed. Also, the farm has a department for Trakenensky breed, and until 2017, there was a department of Russian trotter breeds. The history of the auction trade of pedigree horses in the Moscow stud farm No. 1 dates back to 1971. Horses of several breeds from many pedigree horse breeding enterprises of the country were sold at the auctions. Unfortunately, from 1997 to 2003, auctions were not held, and their functioning was resumed from 2004. This was facilitated by the previously accumulated experience in the rational, well-tested, and approved the organization of tenders. Catalogs for each lot are pre-compiled for the planned auction with photos of the horses for sale, their pedigree data, their performance characteristics, and a description of the parents' sports and prize careers. The potential buyers have the opportunity to familiarize themselves with these materials in advance and directly interact with the horses in the auction stables. Bidding is held twice a year. Riding horses are sold in spring, and trotters are sold in autumn.

For 15 years (from 2004 to 2018), over 230 young pedigree animals of Oryol trotter breeds were sold at annual auctions of the stud farm in the amount of ₽ 44.7 million with an average revenue of ₽ 193.3 for one horse.

The dynamics of the main indicators of the sale of young horses of the Oryol breed at the auctions from 2004 to 2018 are presented in Table 1.

For the analyzed periods, a positive dynamic of production and economic indicators of sales is revealed. In particular, the number of young animals sold in the third period (2014–2018) increased by 35 animals (65.6%) compared with the first period (2004–2008), while the revenue increased from $177.1 thousand to $527.2

Table 1 The dynamics of the livestock and sales proceeds from young Oryol breed auctions

Indicators	Years		
	2004–2008	2009–2013	2014–2018
Horses put up for auction, including	136	149	170
- Sold animals	63	70	98
- Percentage of sales	46.3	47.0	57.7
Sales revenue, $ thousand			
- Total	177.1	271.2	527.2
- Per 1 animal	2.81	3.87	5.38
The dollar exchange rate for the period, ₽	26.84	31.16	58.33
Sales revenue, in terms of ₽ *thousand*			
- Total	4,753.4	8,450.6	30,751.6
- Per 1 animal	75.4	120.7	313.8

thousand, almost three times. In ruble terms, this indicator increased from ₽ 4753.4 to ₽ 30,751.6 thousand, or 6.5 times. A higher level of increase in ₽ revenue was also due to the growth of the dollar exchange rate, from 26.84 to 58.33 ₽, by 26.49 ₽ (117.3%), which in this situation confirms the preferential procedure for calculating auctions in US dollars.

To identify customer preferences, we analyzed the production and economic indicators from sales of stallions and fillies for the period from 2004 to 2018, which are presented in Table 2.

A comparative analysis of the maximum prices for stallions and mares confirms the stable economic superiority of stallions in the sale. The proceeds from the sale of each stallion are higher by $ one thousand (27.0%) or ₽ 60.4 thousand (37.9%).

Table 2 Production and economic indicators of sales at auctions of 1.5 summer stallions and mares of the Oryol trotter breed for 2004–2018

Indicators	Stallions	Mares	Stallions compared with mares (+)
Horses put up for auction, including	236	219	17
- Animals sold	130	101	29
- Percentage of sales	55.1	46.1	9
Sales revenue, $ thousand			
- Total	606.5	369.0	237.5
- Per 1 animal	4.7	3.7	1
Sales revenue, in terms of ₽ *thousand*			
- Total	28,561	16,093	12,468
- Per 1 animal	219.7	159.3	60.4

Table 3 Comparative indicators of sales at auctions of young horses of the Oryol and Russian trotter breeds for 2004–2016

Indicators	Oryol trotter	Russian trotter
Horses put up for auction, including	385	121
– Animals sold	196	45
– Percentage of sales	50.9	37.2
Revenue per sold horse		
– $ thousand	4.0	3.4
– In terms of ₽ thousand	155.9	116.3

It should be assumed that the priority of buyers at the auctions was clearly in favor of the acquisition of stallions, which was associated with the goal of improving the exterior and working qualities of the Oryol trotter on their reproductive farms. One of the motivations for this situation is the high popularity of the Moscow stud farm No. 1 in Russia, which is the flagship for breeding Oryol trotters, which has the most valuable pedigree breed core.

Along with the Oryol trotters in the stud farm in the analyzed period, there was a department of Russian trotters. The young Russian trotter breed was also put up for sale at 13 auctions, excluding sales in 2017 and 2018. A comparison of sales results at the auctions of Oryol and Russian trotters is given in Table 3.

The analysis of the obtained experimental data indicates that the highest interest of the horse owners participating in the auctions is to purchase pedigree horses of the Oryol breed in comparison with the Russian trotter. Thus, the proportion of horses sold in relation to those put up for auction for Russian trotters was 37.2%, and for Oryol was 50.9%, and the average proceeds from the sale of one horse were ₽ 116 and 155 thousand, respectively.

Based on the available reporting data for 2015–2017, we compared the cost of one pedigree horse of the Oryol breed that developed in the three leading farms (horse farms of Khrenovsky, Chesmensky, and Novotomnikovsky) with the price at the auction for these years. The cost of a pedigree horse in these stud farms, when sold in the usual manner, amounted to an average of ₽ 89.4 thousand, while at an auction, the cost was ₽ 153.8 thousand, which is ₽ 64.4 thousand or 72.0% higher.

4 Discussion

With the destruction of the planned and directive economy, pedigree horse breeding has lost the main reserves of financing for self-sufficient development. Simultaneously, successful foreign experience shows that the primary source of income for reproductive horse farms is the funds from the sale of young breeding horses at the auctions as well as the deductions from national horse sweepstakes [5, 8].

The assessment's in-depth studies reveal two ways of selling pedigree horses in the analyzed farm, which confirm the superiority of auction sales, as it provides significant economic benefits. In particular, the average price of one horse of the Oryol trotting breed at the auction was more than 1.7 times higher than the actual price of a horse during a standard sale in typical stud farms. To increase the efficiency of the domestic market for pedigree horses, it is recommended that the country expand its network of permanent auctions for the sale of pedigree horses of different breeds.

5 Conclusion

In current economic conditions, the successful solution of the problems of efficient and sustainable, cost-effective pedigree horse breeding is possible, based on the integrated implementation of innovative organizational, technological, and breeding measures.

The studies have found that one of these activities, contributing to a significant revitalization of the domestic market for pedigree horses and increasing the marketability of the industry as a whole, is a progressive, off auction form of selling young pedigree animals at an early age.

Acknowledgements The authors express their gratitude for the provided advice and financial support to V. V. Kalashnikov, Doctor of Agricultural Sciences, Professor, Academician of the Russian Academy of Sciences, Scientific Director of the Russian Research Institute of Horse Breeding, as well as to A. M. Zaitsev, Candidate of Agricultural Sciences, Director of the Russian Scientific Research Institute of Horse Breeding.

References

1. Bochkarev, V.A., Eremina, V.E.: A brief overview of the technology of reproduction and maintenance of pedigree horses at Winback Stud Farm (USA). Horse Breed. Equest. Sport **6**, 34–35 (2009)
2. Bosalaeva, E.V.: The analysis of sales at the Goffe auction. Horse Breed. Equest. Sport **6**, 11–12 (2006)
3. Kalashnikov, V.V.: Strategy and tactics of development of breeding horse breeding. Achiev. Sci. Technol. AICis **10**, 12–14 (2008)
4. Kalashnikov, V.V., Kalashnikov, R.V.: From problems to development economics: learning from the experience of others. Horse Breed. Equest. Sport **5**, 4–7 (2018)
5. Kalashnikov, V.V., Zaitsev, A.M., Koveshnikov, V.S. et al.: Horse industry of beit and road countries. Beijing, China (2018)
6. Koveshnikov, V.S.: Horse breeding economics. Horse Breed. Equest. Sport **3**, 6–7 (1987)
7. Koveshnikov, V.S., Bochkarev, V.A.: Organizational and economic problems of the prize trotting horse breeding. Horse Breed. Equest. Sport **4**, 6–8 (2006)
8. Martin, V.: The black book. Hanover, PA (2008)
9. Timchenko, A.M.: Horse breeding after the third Russian congress of horse breeders. Horse Breed. Equest. Sport **6**, 2–3 (2007)

Problems and Directions of the Improvement of Price Relations in the Russian Agricultural Sector of Economy

V. V. Maslova, N. F. Zaruk, and M. V. Avdeev

Abstract The purpose of the paper is to assess the current state of prices and price relations in the agricultural sector of Russia. The authors analyzed the dynamics of prices of agricultural products, industrial products, food products, and processing industry, consumer prices in the period 2014–2018. The authors consider the cost structure of agricultural production, which is the basis of balanced price relationships. The study showed that the increase in prices of agricultural producers in recent years was significantly less than in other sectors of the economy. This leads to an increase in disproportions and to a decrease in the financial stability of agricultural producers. The most significant disproportions in price relations are formed in the sale of food products in retail trade. The study compares the average prices of agricultural producers in Russia with the prices of producers in the countries leading in terms of exports of these products in the world. Such a comparison allows to determine that crop production (wheat and sunflower seeds) has a price competitiveness in the world market. The authors provide a number of proposals to improve price relations in the agricultural sector of Russia. The proposals are aimed at the balanced development of agriculture: in the sphere of relations between agricultural producers and resource-providing industries, in the field of production, as well as in the field of ensuring the balance of supply and demand.

Keywords Agriculture · Prices · Price relations · Cost · Producer price · Price regulation

1 Introduction

In modern economic conditions based on market pricing, price plays a major role in the system of the regulation of reproduction in the agricultural sector. It is through the price system that the largest amount of financial resources is accumulated.

V. V. Maslova (✉) · N. F. Zaruk · M. V. Avdeev
Federal Research Center of Agrarian Economy and Social Development of Rural Areas—All-Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: maslova_vlada@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_60

The current regulatory framework in Russia for pricing and the development of price relations, including in the agricultural sector of the economy, remains consistently liberal. This allows business entities to determine the conditions for interaction among themselves independently. However, due to the seasonality of production, significant fluctuations in the prices of products sold throughout the year, the dependence of revenue on the production cycle, as well the price dynamics in other sectors of the economy, the agricultural producer becomes one of the least protected business entities.

At various stages, in the formation of market relations (since the late 1990s), the government made attempts to regulate price proportions between agriculture and industries by compensating agricultural producers for losses associated with rising prices for acquired means of production, as well as by setting levels of marginal prices on purchased agricultural products. Currently, a comprehensive system of measures for stabilizing the price situation on the agri-food market is absent [9].

A study of foreign experience in regulating the price situation of the agri-food market shows that almost all developed countries in the world are actively introducing various stabilization mechanisms. Many of them are fixed in laws and other regulatory legal acts, with the allocation of financial resources for these purposes, such as in the USA and China [4, 5].

2 Materials and Methods

In order to analyze the dynamics of prices and price relations in the agrarian sector of the Russian Federation, the methods of statistical groupings and statistical analysis of time series characterizing the indicators of price movements were used. The research information base was compiled with data from the Federal State Statistics Service, the Ministry of Agriculture of the Russian Federation, the Food and Agriculture Organization of the United Nations (FAOStat), and other official sources of information.

3 Results

Price is a category of commodity-money relations; therefore, the pricing theory, which reveals the patterns, methodology, development, and practice of pricing, changes and improves in accordance with the evolution of economic relations.

In our opinion, at present, the basis of pricing, including the agri-food market, is the interrelation of cost and market pricing mechanisms, expressed in a combination of accounting for production costs and profits, on the one hand, and the ratio of supply and demand, on the other hand. Let us consider these aspects in more detail.

First, balanced pricing relations imply building an optimal cost structure, which is ensured by increased crop yields, animal productivity, and labor productivity through the use of innovative technologies that help to reduce production costs.

The cost estimate shows that despite the fact that the share of costs has increased for some items and has decreased for others, the absolute costs per unit of output for all items have significantly increased. As a result, production costs for many types of products compared to the level of 2008 in comparable prices increased more than 2 times.

Based on the cost analysis (based on expert estimates) from 1990 to 2017, the significant structural changes were observed: the share of material costs increased 1.5 times, and the share in the cost structure of all purchased goods and services increased especially sharply due to the growth of their prices. For example, the proportion of petroleum products increased in 2000 almost 6 times to the level of 1990 and 2.6 times by 2017, respectively [10]. In this regard, the share of cost in the price of agricultural products increases, and the profit and competitiveness of products decrease [7].

Second, the balance of price relations depends on the dynamics of prices and price relations in various sectors of the economy related to agricultural production, processing, and sales.

In recent years, the dynamics of market prices in Russia have been unstable. This instability is especially pronounced in fluctuations in producer prices of agricultural products [1]. The prices rise substantially, and then rapidly fall. At the same time, prices for goods and services purchased by agricultural producers have a stable upward trend. These processes have resulted in a deterioration in price ratios. Thus, between 2014 and 2018, the growth of prices for agricultural products amounted to 23.9%, while the prices of the industrial means of production increased by 42.1% (Fig. 1).

The agricultural producers act on the market not only as sellers of agricultural raw materials and food but also as buyers of finished products. Therefore, equally

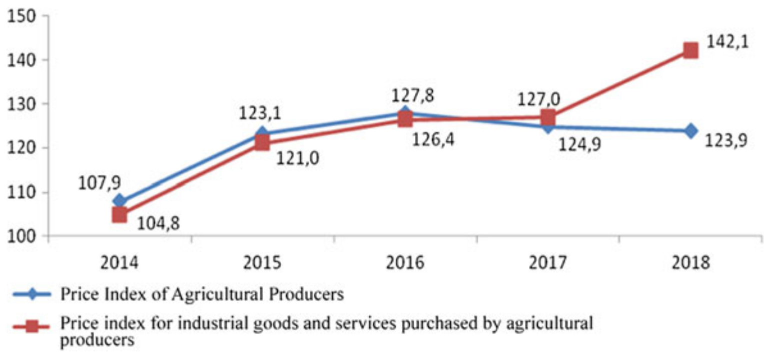

Fig. 1 The dynamics of the producer prices of agricultural products and the prices of industrial means of production in Russia in 2014–2018 (in % to 2014). *Source* Calculated by the authors based on the Rosstat data [2]

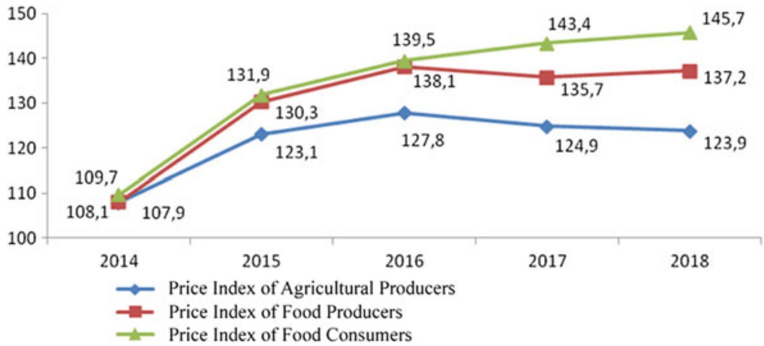

Fig. 2 The dynamics of producer prices of agricultural and food products, consumer prices for food in Russia in 2014–2018 (in % to 2014). *Source* Calculated by the authors based on the Rosstat data [2]

important aspects are consumer prices and the price relationship between agriculture and enterprises that process agricultural raw materials.

The analysis showed that in the ratios between agriculture and the food industry, a significant imbalance was formed in favor of the latter (Fig. 2).

The price index of food producers is 13.3% higher (137.2%).At the same time, the highest price increase was recorded in the retail trade in food products: 145.7% (21.8% higher than agricultural producers). Over a five-year period, the increases in the price of agricultural producers were substantially less than growth in other sectors of the economy.

Thus, the data indicate that the maximum imbalances in price relations are now formed when selling food products in retail. At the same time, the state almost eliminated itself from price regulation of trading in food products. In essence, at present, only the provision “on the right to set maximum allowable retail prices for socially important essential food items” is in force if retail prices increase by more than 30% within a month [3].

The ongoing integration processes between countries and the strengthening of foreign trade interactions largely determine the direction of price formation in the domestic market and affect price proportions in the agri-food sector. In this regard, the analysis of price ratios between domestic and world prices is of particular relevance.

The calculation of the ratio of average producer prices in Russia and in the leading countries for the export of these products in the world (top five) showed that domestic crop production (particularly wheat and sunflower seeds) has significant competitiveness at the production level. However, for livestock products of almost every type under consideration, the price ratio was in favor of world leaders in terms of export volume (Table 1).

The analysis allows us to conclude that domestic products are price competitive at the level of production. However, this was not due to the optimization of production and cost reduction. The main factor in increasing competitiveness was the devaluation

Table 1 The correlation of average producer prices in Russia with producer prices of world leaders in terms of exports in 2017

Production	Top 5 exporting countries				
Wheat	USA	Australia	Canada	Ukraine	France
	0.74	0.71	0.69	0.87	0.79
Potato	France	Germany	Netherlands	Belgium	Egypt
	0.73	1.01	1.11	1.56	1.20
Sunflower seeds	Romania	Bulgaria	France	Hungary	Slovakia
	0.86	0.80	0.73	0.80	0.83
Sugar beet	Germany	Slovakia	Hungary	Serbia	Belgium
	1.13	1.35	1.24	0.97	1.54
Cattle (live weight)	USA	Netherlands	Ireland	Poland	Canada
	0.64	1.14	0.72	1.00	0.71
Pigs (live weight)	Germany	USA	Denmark	Canada	Netherlands
	1.17	1.41	1.43	1.40	1.24
Chicken (live weight)	Brazil	USA	Netherlands	Poland	Belgium
	1.07	0.97	1.26	1.31	1.20
Milk, raw (cattle)	Germany	France	Netherlands	United Kingdom	Czech
	1.02	1.06	1.05	1.17	1.16

Source Calculated by the authors based on the FAOStat data [8]

of the national currency, which caused a decrease in average producer prices in terms of US dollars and a corresponding change in price ratios [6].

4 Discussion

One of the possible ways for improving the price relations between agriculture and industries is to limit the increase in prices for material resources used in the industry. This is especially true for markets with a dominance of state-owned companies. It is also advisable to prevent a reduction in the volume of subsidies provided to manufacturers of agricultural machinery.

In order to improve the price relations between agriculture and enterprises processing agricultural raw materials, as well as the sphere of trade, it is necessary to form a comprehensive system of measures, both in the sphere of production of goods and in the sphere of ensuring the balance of supply and demand.

In the field of production and sales of products, this includes optimization of the cost of agricultural products based on the use of innovative technologies; formation of forecast balances for agricultural raw materials and food; ensuring the conformity of the raw material base to the capacities for storage, transportation, and processing of products; improving state support for the development of commodity distribution logistics systems; maintaining tax benefits for agricultural organizations of the agricultural sector; and digitalization development.

In the field of ensuring the balance of supply and demand, this includes introduction of the minimum guaranteed prices for the main types of products; development of stock exchange instruments; introduction of a system of constant monitoring of prices and informing all participants in the food chain ("from the field to the counter"); control over the structure of retail prices for a wide range of food products in the context of the main federal and regional food retailers; and increasing the purchasing power of the population.

These measures for improving price relations in the agricultural sector of Russia will also allow the growth of the competitiveness of domestic products in the world market.

5 Conclusion

Thus, to equalize price relations in the agricultural sector, the creation of an integrated system for their optimization is required. It should consist of a set of measures for regulating price relations between resource-supplying sectors, agriculture, food industry, and trade. This will create the necessary basis for the sustainable development of the agricultural sector of the economy.

References

1. Borkunov, N.A., Avdeev, M.V.: Price parity in the agro-industrial complex of Russia and the EAEU member states. AIC: Econ. Manag. **3**, 60–68 (2018)
2. Federal State Statistics Service: Official website. Retrieved from https://www.gks.ru (n.d.)
3. Government of the Russian Federation: Decree "On the approval of the rules for setting maximum allowable retail prices for certain types of socially significant food essentials" (July 15, 2010 No. 530). Retrieved from https://base.garant.ru/12177401/ (2010)
4. Lev, M.Yu.: Pricing in China during reforms and crisis situations: regulatory aspect. Bull. Moscow Acad. Entrepreneurship Under Gov. Moscow **3**, 149–155 (2014)
5. Maslova, V.V., Avdeev, M.V., Orshanskaya, Yu.O.: Regulation of prices and price relations in the agro-industrial complex of Russia and abroad. Econ. Agric. Process. Enterprises **11**, 13–18 (2018)
6. Maslova, V.V., Zaruk, N.F., Avdeev, M.V.: The production and competitiveness of grain and products of its processing in the EAEU member states. Econ. Agric. Process. Enterprises **9**, 19–24 (2017)
7. Ministry of Agriculture of the Russian Federation: Official website. Retrieved from https://www.mcx.ru (n.d.)
8. Statistics of Food and Agriculture Organization of the United Nations: Official website. Retrieved from https://www.fao.org (n.d.)

9. Ushachev, I.G., Maslova, V.V., Chekalin, V.S.: State support for agriculture in Russia: problems, solutions. AIC: Econ. Manag. **3**, 4–12 (2018)
10. Zaruk, N.F.: The analysis of the formation and management of production costs in agricultural organizations. Econ. Labor, Manag. Agric. **11**, 63–69 (2018)

The Impact of State Support on the Profitability of Agricultural Enterprises in the Altai Region

Tatiana I. Valetskaya, Viktoria V. Vorobyova, and Natalia A. Torgashova

Abstract The development of agriculture is determined by many factors. Some of them are associated with the negative impact of the external environment, the imperfection of relationships in the agricultural sector. In these conditions, state regulation of agrarian production is necessary for increasing the efficiency of the functioning of commodity producers, saturating the food market in the required quantity and quality. In the Altai Territory, the priority is given to enterprises with a diversified economy (dairy and beef cattle farms have additional coefficients) when distributing budgetary funds. However, practice shows that most of the budget (about 46.1%) is concentrated in grain and dairy farms, with a predominance of grain or milk in the structure of marketable products. The authors prove that when improving the state support system, it is necessary to take into account the investment activity of enterprises, since the risks of such organizations are significantly higher, and the return on invested funds is higher.

Keywords State support · Agriculture · Economic efficiency · Agricultural enterprises

1 Introduction

State support for agricultural production is a system of economic, organizational, and legal measures aimed at creating favorable conditions for production, processing, transportation, procurement, storage, industrial and technical maintenance, and the

T. I. Valetskaya · N. A. Torgashova
The Altai Branch of the Russian Presidential Academy of National Economy and Public Administration, Barnaul, Russia
e-mail: tativval@mail.ru

N. A. Torgashova
e-mail: torgashova@alt.ranepa.ru

V. V. Vorobyova (✉)
Altai State University, Barnaul, Russia
e-mail: vvvtoria@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_61

material and technical supply of agricultural development. The industry specifics and difficulties of forming the economic mechanism of commodity producers in agriculture significantly complicate the development of alternative options for implementing the program, comparing their effectiveness, and choosing the best. The complexity of this kind of task and the imperfection of the applied methods often lead to the fact that budget funds allocated to solve the system-wide problems of the agricultural economy are not used in the best way. As a result, a number of researchers note the instability and inconsistency of the state's economic policy in regard to supporting agricultural producers, which is characterized by a loss of targeting, a weak orientation towards reducing production costs, and improving the quality and efficiency of production. It is based on the equalizing mechanism, and its regionalization leads to the breaking of inter-farm relations inside the country [2, 3, 5].

Budget funds for the creation of conditions for the development of agricultural production in the Altai region are carried out in accordance with federal law "On the Development of Agriculture"; the state program for the development of agriculture and regulation of agricultural products, raw materials, and food markets; and the law of the Altai region "On the Development of Agriculture in the Altai region." The embargo on the import of agricultural products, raw materials, and food from a number of foreign countries aggravated the problem of import substitution of basic food products. This circumstance required a review of the state's agrarian policy and a reassessment of previously adopted programs and projects for the development of the agro-industrial complex (AIC), taking into account the introduction of additional measures to support the agricultural sector. In order to implement the decisions adopted by the Government of the Russian Federation in the field of food security at the regional level, the active work of implementing the measures of state support for the agricultural sector is underway. In particular, one of the features is the presentation of budgetary funds in the Altai region for unrelated support in crop production—the adjustment of base rates for coefficients that take into account the location of enterprises in the natural and climatic zones of the region and the degree of diversification of their activities.

2 Materials and Methods

The theoretical and methodological basis of the study was the result of scientific research in the implementation of state agricultural development programs. In the research process, general scientific (scientific abstraction, inductive, deductive, comparative analysis) and special approaches were used. Such special methods as comparison, monographic, economic, and statistical (statistical sampling, economic grouping, calculation of statistical indicators, including average, absolute, and relative values) were used. For the analysis of statistical data, the Microsoft Office software package was used. The sources of statistical information were Rosstat, its territorial bodies, and data from the Ministry of Agriculture of the Altai region.

3 Results

State support for agricultural producers in the Altai region is currently carried out in the framework of regional state programs "Development of Agriculture in the Altai region" for 2013–2020, "Development of Land Reclamation of the Altai region for Agricultural Purpose for 2014–2020," "Sustainable Development of Rural Areas of Altai region for 2012–2020," which complement the State Program for the Development of Agriculture and the regulation of agricultural markets, raw materials, and food for 2013–2020.

Within the framework of these programs, about 62% of all budget funds in 2017 were transferred under two subprograms ("Development of the livestock sub-sector" and "Development of the plant-growing sub-sector"). The purpose is to create economic and technological conditions for sustainable development and increase the competitiveness of products. As part of livestock breeding, 53% of budget subsidies were allocated for increasing the productivity of dairy cattle breeding and support the development of pedigree livestock breeding (Fig. 1). The livestock breeding base is a major factor in increasing the productivity of dairy farming. In this regard, in 2017, the volume of support for livestock breeding was doubled, compared to 2016.

Simultaneously, it should be noted that due to the change in legislation that regulate the provision of support for the reimbursement of a portion of the costs of interest payments on loans and borrowings, the investment and short-term loans issued after 31 December 2016 are not subject to preferential subsidies. Therefore, subsidies for the compensation of the interest rate in 2017 decreased by almost three times, compared to 2016.

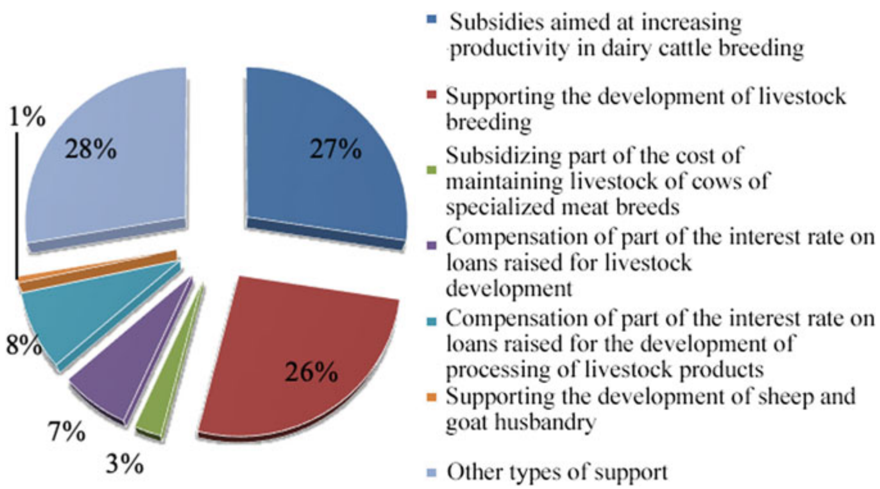

Fig. 1 The structure of state support for the development of animal husbandry in the Altai region in 2017, %

As part of the crop production's development, 67% of the funds were allocated for the provision of unrelated support in the field of crop production (Fig. 2), introduced in 2013 and taking into account the requirements of the WTO to expand measures related to the green "box" [4]. These subsidies are provided to reimburse part of the costs of a complex of agrotechnological work, increase the level of environmental safety of agricultural production, and increase fertility and soil quality per 1 hectare of sown area of crops. This area has replaced a number of previously existing areas of support: compensation for the cost of chemicals and mineral fertilizers, sale of fuels, and lubricants at preferential prices. When determining the sizes of hectare subsidies in the region, a differentiated approach is used, taking into account the difference in the climatic conditions of production as well as the need to provide additional support to farms engaged in dairy and beef cattle breeding or the cultivation of sugar beets.

When this subsidy was allocated by a decree of the government of the Altai region called "On Approving The Procedure For Providing Subsidies From The Regional Budget For The Provision Of Unrelated Support In The Field Of Crop Production" (February 2017 No. 34), a number of conditions for providing support were introduced: the achievement of the minimum wage level in the industry, no debt in the budget and extrabudgetary funds, the presence of concluded agricultural insurance contracts, and others.

In addition, within the framework of this resolution, subsidy rates for 1 ha of sown area were determined with the division of enterprises into two groups:

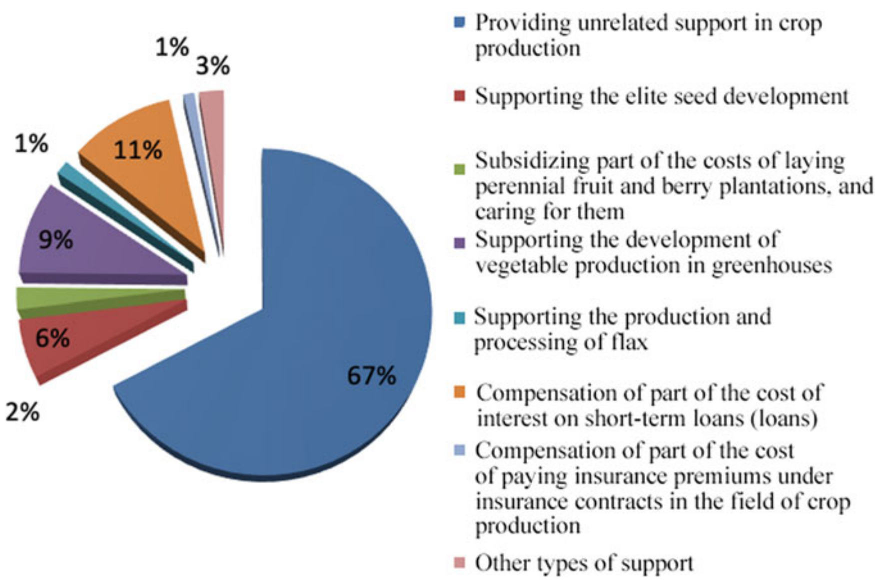

Fig. 2 The structure of state support for the development of crop production in the Altai region in 2017, %

- the enterprises engaged in the cultivation of crops and the production of milk or cattle meat (at least 300 dairy cows or at least 200 meat breed animals);
- the enterprises engaged in the production of only crop products or having a population below the established minimum criteria (for these organizations, the specific rate of budget funds is 30% lower).

Thus, on the one hand, the state supports and stimulates the development of dairy and beef cattle breeding, but on the other hand, it places unequal conditions on other producers that specialize in crop production. At the same time, the differentiation of subsidies for unrelated support by natural and climatic zones made it possible to equalize the conditions for agricultural industries in the context of the natural and climatic zones of the region (Table 1).

The main type of subsidies (42.4–48.8%) for enterprises in the arid and low-humid zones (with a hydrothermal coefficient [hereinafter HTC] 0.6–0.8) were the support in the form of unrelated support in the field of crop production, for which a differentiated distribution approach has been applied since 2013.

In humid areas (HTC 1.1–1.6) in 2017, the receipt of state support by agricultural enterprises was divided between three types: the subsidies for unrelated support to agricultural producers in the field of crop production, the subsidies for increasing productivity in dairy cattle breeding, and the subsidies for supporting pedigree livestock.

When determining the close relationship between the funds issued by the state and the results obtained, a direct and close relationship was found between the yield of grain crops and the profit from sales (the correlation coefficient was 0.65–0.88). At the same time, there is an inverse tightness of connection with the level of profitability (−0.19), which indicates that budget funds are redistributed to enterprises with a lower level of profitability (Table 2). As a result, budget subsidies compensate for part of the costs of enterprises in which long-term investments are required to increase production volumes (purchase of breeding animals, elite seeds, machinery, construction of cowsheds, etc.) [1].

4 Discussion

When studying the influence of state support on the efficiency of specialization of agricultural enterprises, an inverse relationship was found between the issued funds and the obtained results (Table 3). Thus, about half of all enterprises in the region of the grain type received only 12.3% of budgetary funds, while, on average, the subsidies amounted to ₽ 190.4 rubles per 1 subsidiary plow ha., while at the same time, dairy enterprises (14.58%) received 33.8% of all funds issued (₽ 868.8 on 1 ha. of arable land). The largest amount of subsidies was received by the enterprises engaged in the production of cattle meat ₽ 1922 per 1 ha of arable land, however, even with such a level of support from the state, the activities of such enterprises remain unprofitable.

Table 1 The structure of state support for agricultural enterprises in the climatic zones of the Altai region in 2017, %

Support directions	Hydrothermal coefficients (HTC)						
	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.6
The subsidies for the provision of unrelated support to agricultural producers in the field of crop production	48.8	46.5	42.4	22.3	37.7	35.9	26.4	23.7
The subsidies to support elite seed production	1.7	4.7	3.8	1.6	2.2	8.5	0.7	–
The compensation of part of the interest rate on short-term loans in the field of crop production	2.4	2.1	8.5	14.0	0.9	8.5	5.6	0.5
The subsidies for increasing productivity in dairy farming	12.2	15.5	15.8	15.7	29.9	10.7	16.3	27.3
The support of livestock breeding	20.3	11.0	8.5	19.0	10.8	5.5	17.8	18.7
The compensation of part of the interest rate on short-term loans for the development of production and processing of livestock products	0.5	8.6	0.2	2.4	–	5.7	9.0	–
The subsidies for the reimbursement of part of the interest rate on investment loans in the agricultural sector	5.1	7.7	10.9	17.1	10.0	7.2	8.0	4.2
Other	9.0	3.9	9.9	7.9	8.5	18.0	16.2	25.6
TOTAL	100	100	100	100	100	100	100	100

Source Compiled by the authors on the basis of annual reports of large and medium-sized agricultural enterprises of the region

Table 2 The impact of state support on the production and financial performance of agricultural enterprises in the Altai region

HTC	Budget funds per 1 ha of arable land, ₽	Crop yield, kg/ha	Annual milk yield per 1 cow, kg	Profit from sales per 1 ha of arable land, thousand ₽	Profitability, %
0.6	518.2	11.4	3908	1.2	18.7
0.7	426.7	13.6	4305	1.4	18.9
0.8	386.6	14.1	4029	1.9	22.0
0.9	447.6	17.7	5799	2.7	24.0
1.0	465.6	14.6	4991	2.2	37.0
1.1	486.2	16.0	3815	2.0	19.3
1.2	1057.2	20.2	5373	5.0	21.4
1.6	659.2	14.3	3579	2.5	15.2

Source Compiled by the authors on the basis of annual reports of large and medium-sized agricultural enterprises of the region

Table 3 The relationship of the received budgetary subsidies and production and financial performance results in the framework of production types of agricultural enterprises of the Altai region in 2017

Production types of enterprises		% of the total number of enterprises	% of budget funds in their total amount	Subsidies per 1 ha of arable land, ₽	Profit per 1 enterprise, thousand ₽	Profitability (loss ratio) of production, %
Enterprises with 1 main industry, specific gravity not less than 50%	Grain	48.52	12.3	190.4	4406	17.55
	Milk	14.58	33.8	886.8	13,191	15.35
	Sunflower	6.71	2.9	219.2	11,791	28.48
	Cattle meat	2.97	4.9	1922.0	−186	(0.58)
	Pig meat	0.65	0.4	439.6	5213	4.30
Enterprises with 2 main industries, specific gravity not less than 33.3%	Grain, milk	1.93	2.4	626.7	9397	10.45
	Milk, cattle meat	0.26	0.1	434.5	86	0.80
	Cattle meat, grain	0.39	0.4	185.0	−5025	(11.42)
	Grain, sunflower	0.78	0.7	365.1	14,728	30.34

Source Compiled by the authors on the basis of annual reports of large and medium-sized agricultural enterprises of the region

Among enterprises with two main industries, the largest amount of subsidies was given to grain-and-milk-type enterprises, but the highest level of profitability was observed in the enterprises engaged in the production of grain and sunflower; however, such enterprises in the region are less than 1% [6].

All of the above indicates that a state support system has been formed in the region. It takes into account climatic conditions and a number of other conditions (increasing coefficients for agricultural producers, in which the yield of grain and leguminous crops in the previous year was higher than the district average; raising subsidy rates for farms involved in animal husbandry; and mandatory testing of seeds of grain and leguminous crops for sowing quality), but not taking into account the specialization of agriculture farm enterprises and their production types. Ultimately, this affects the efficiency of agricultural producers.

5 Conclusion

The studies have shown that in order to ensure food security of the country and the region, as well as mitigate adverse environmental conditions and the influence of several other factors, state support is provided in the Altai region. It is done by providing budget subsidies in various areas as part of the implementation of state programs in the field of agricultural development. Budget subsidies are differentiated by climatic zones. The increased ratios, increasing subsidy rates in order to use funds more efficiently and increase production, are used for a number of categories of farms.

However, enterprises engaged in the production of cattle meat are still ineffective due to high production costs. In this regard, in the future, a comprehensive work in the framework of intensification of meat production, including strengthening government support measures and implementing internal factors to increase production efficiency, should be carried out.

References

1. Bogoviz, A.V., Vorobyov, S.P., Vorobyova, V.V.: Economic efficiency of specialization of agricultural enterprises of the dairy type. AIC Econ. Manag. **2**, 62–68 (2017)
2. Bozhchenko, J.A.: The Mechanism for the Implementation of Economic Interests in Agricultural Organizations. Prospect, Moscow, Russia (2017)
3. Mazloev, V.Z.: The adaptation of the economic mechanism of the agro-industrial complex to sanctions. Econ. Agric. Process. Enterp. **2**, 28–31 (2015)
4. Uzun, V.Y.: Limiting the amount of subsidies to one agricultural producer: necessity, mechanisms, consequences. AIC Econ. Manag. **11**, 12–31 (2017)
5. Uzun, V.Y., Shagayda, N.I.: The Agrarian Reform in Post-Soviet Russia: Mechanisms and Results. Delo, Moscow, Russia (2015)
6. Vorobyov, S.P., Gritsenko, G.M., Vorobyova, V.V., Walecka, T.I.: The financial condition of agricultural organizations with a different combination of industries. Econ. Agric. Process. Enterp. **12**, 36–39 (2017)

The Method of Computer Morphometry in the Analysis of Vegetable Seeds

Farkhad B. Musaev, Nikolay S. Priyatkin, and Mariya I. Ivanova

Abstract The instrumental innovative methods for analyzing the quality of seeds have recently come to replace the traditional standard methods. The traditional methods differ unfavorably from instrumental ones, particularly in labor intensity, duration of plumpness, and information content. At the same time, with the introduction of new agricultural technologies in crop farming, the requirements for the quality of seeds are increasing. The paper focuses on the adaptation of the method of digital morphometry in relation to the seeds of vegetable crops. The matrix heterogeneity of the *Persian onion* seeds, driven by the different-tiered arrangement within the inflorescence, is analyzed. The research demonstrates that as the inflorescence grows, the seeds decrease in size and are less fulfilled. Within the inflorescence, the different quality of the seeds is expressed as follows: as we move away from the base of the inflorescence, the seeds acquire a darker color and become less mature. The authors conclude that digital morphometry is more accurate than the "manual" one. Their analysis of the smallest seeds of the *perennial wall-rocket* variety shows that different batches of seeds significantly differ in size characteristics against each other. We believe that there is no alternative to digital morphometry in these measurements. The innovative instrumental digital method of seed morphometry *VideoTesT-Morphology* (Argus-BIO) can be successfully used to assess the quality of seeds of vegetable crops, both by their linear parameters and by coloring the surface of the seeds.

F. B. Musaev
Federal Scientific Vegetable Center, pos. VNIISSOK, Odintsovo, Moscow, Russia
e-mail: musayev@bk.ru

N. S. Priyatkin
Agrophysical Research Institute, Saint-Petersburg, Russia
e-mail: prini@mail.ru

M. I. Ivanova (✉)
All-Russian Scientific Research Institute of Vegetable Growing – Branch of the Federal Scientific Center for Vegetable Growing, Vereya, Ramensky, Moscow, Russia
e-mail: vniioh@yandex.ru; vilarnii@mail.ru

All-Russian Scientific Research Institute of Medicinal and Aromatic Plants, Moscow, Russia

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_62

Keywords Seed · Shape · Digital morphometry · Linear parameters · Surface color · Persian onion · Perennial wall-rocket

1 Introduction

The modern level of development of agricultural production and agronomic science requires the use of innovative instrumental methods, characterized by high information content and accuracy. The analysis of literary sources [3, 4, 5, 9] indicates a wide application of biophysical methods for the analysis of seed quality, which allows a deeper understanding of the nature of the formation of high-quality seed material. Computer technology has penetrated deeply into all spheres of human life, including science. In seed science, computer technologies have come to replace routine work (manual morphometry of the seeds). Foreign scholars are actively using the technology of computer analysis of seed images [6, 10].

The shape of the seed is considered one of the most stable morphological indicators. According to the shape, it is possible to judge the sowing qualities of seeds: to determine the degree of their performance and the level of humidity [7]. The plumpness of the seeds is the evidence of their ideal shape. Seed cleaning and sowing machines and mechanisms are designed according to the shape of seeds [1, 12]. In our early works [8, 11], the shape of the seeds was determined by manually measuring their linear parameters, which was due to the complexity and measurement error. Now, it is possible to perform digital analysis of the images of the seeds of vegetable crops to determine their shape.

The purpose of the study is to apply and adapt digital morphometry to vegetable crop seeds, to analyze their quality by determining the size, shape and color of the surface of the seeds.

2 Materials and Methods

The object of the study is an innovative instrumental method for analyzing seeds of different quality—digital morphometry of scanned images of seeds. The materials researched are the seeds of the *Persian onion* (*Allium cristophii* Trautv.) and *perennial wall-rocket* (*Diplotaxis tenuifolia* DC. (L.)) from the biology collection of VNIIO, which is a branch of the Federal State Budget Scientific Institution of the Federal Scientific Research Center in the Moscow region.

Digital seed morphometry was carried out using the VideoTesT-Morphology serial software (Argus-BIO), produced by ArgusSoft, LLC, St. Petersburg [2].

The digital images of the seeds were obtained using the digital flatbed scanner *HP ScanJet 200*, and the format of the saved file is TIFF. The algorithm for software processing of the digital images of seeds includes the following basic operations: calibration (reference to real dimensional values), the selection of a region of interest, automatic threshold selection of objects of interest (seeds) by color or brightness, automatic measurement of selected objects of interest, and export of the measurement table to MS Excel.

3 Results and Discussion

The different quality of Persian onion seeds was due to their different tier arrangement on the inflorescence, which is called the matrix of different quality. The data on the digital morphometry of seeds collected from different tiers (vertically) of inflorescences of seed plants are presented in Table 1 and Fig. 1. The analysis of the dimensional characteristics (projection area, width) of the seeds revealed a tendency to a decrease in the size of seeds from the lower tier to the upper tier, which is associated with different nutrition and seed-loading conditions. These differences, although within the margin of error, are, at the same time, biased.

The capabilities of the program *VideoTesT-Morphology* (Argus-BIO) are not limited to the measurement and calculation of the linear parameters of seeds; it is also possible to determine the colors and shades of the surface of seeds. The color of the seeds allows us to judge the degree of their ripeness, which is the most important characteristic of their quality. This is especially important for most regions of our country, with limited light and heat supply.

The analysis of the color characteristics of different-quality seeds of Persian onions (the values of the color components according to the RGB model) revealed a statistically significant decrease in all color channels in the row from the lower tier to the upper; that is, the seeds collected from the lower tier of the testis have a lighter color, and from the upper, darker (Table 2; Fig. 2). The seeds from the lower tiers are better fed and ripen more fully. Therefore, the lighter the onion seeds, the more mature and full-fledged they are.

We set up the program for the analysis of small seeds by carefully selecting the modes and background for scanning and analyzed in a trial order the seeds of five batches of the different-quality seeds of the perennial wall-rocket. The seed size (projection area) averages to about 1 mm^2 (Fig. 3; Table 3).

However, even such “microscopic” seeds in linear sizes significantly differ between batches (Table 3), which makes it possible to use the program for the morphometric analysis of the different quality of small seeds.

It should be noted that in this case (when working with small seeds), there is no alternative to digital analysis since mechanical measurement is impossible here.

Table 1 Linear parameters of the matrix-different-quality seeds of Persian onion

Parameters tiers indicators	Area, mm^2			Perimeter, mm			Length, mm			Width, mm		
	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Minimum	4.18	3.48	4.58	7.61	7.05	8.03	2.62	2.73	2.77	2.00	1.73	1.95
Maximum	8.55	8.15	8.90	10.6	10.3	10.6	3.66	3.87	3.75	3.21	3.07	3.33
Average	6.57	6.42	6.26	9.34	9.25	9.17	3.30	3.29	3.26	2.68	2.60	2.58
Standard deviation	0.87	0.77	0.79	0.58	0.53	0.52	0.22	0.22	0.22	0.23	0.21	0.22
Relevance	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Confidence interval	0.17	0.16	0.15	0.11	0.11	0.10	0.04	0.04	0.04	0.04	0.04	0.04

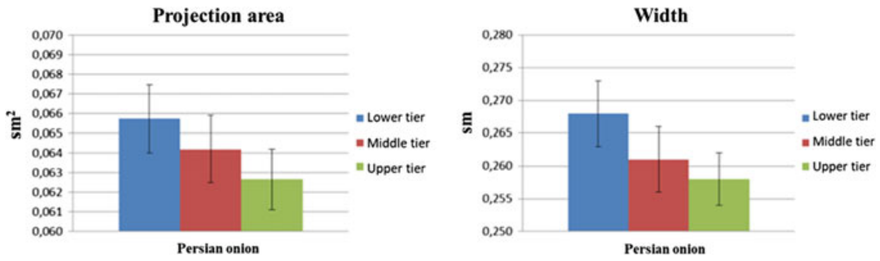

Fig. 1 Linear parameters of matrix-different-quality seeds of Persian onion

Table 2 The morphometry of coloring of materially different quality seeds of Persian onion

The tiers of inflorescences	Red, unit of brightness	Green, unit of brightness	Blue, unit of brightness	Tone, relative unit	Saturation, relative unit
Lower	40.820	40.436	42.347	0.715	0.023
Middle	38.548	38.129	39.906	0.691	0.027
Upper	36.533	36.118	38.242	0.709	0.031
HCP_{05}	2.53	2.32	2.48	0.046	0.004

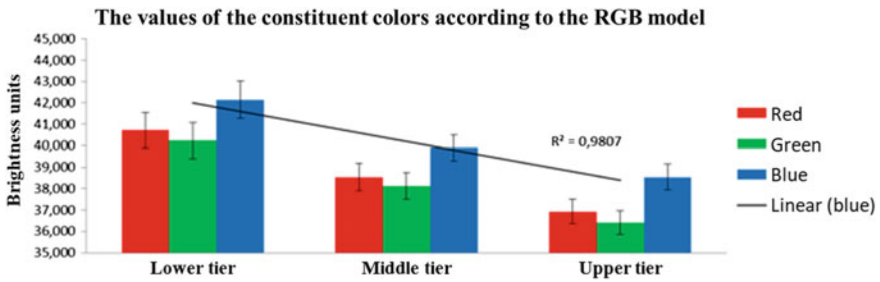

Fig. 2 The morphometry of coloring of materially different seeds of Persian onion

4 Conclusion

1. The information content of the digital morphometry method and the accuracy of measurements allow us to judge the matrix of seeds of different quality, due to their different tier arrangement on the mother plant, and within the inflorescence.
2. The degree of ripening rate of the seed can be successfully determined by analyzing the color characteristics of its surface on the scale of the additive RGB color model.
3. The method of digital morphometry in the analysis of small seeds has practically no alternative.

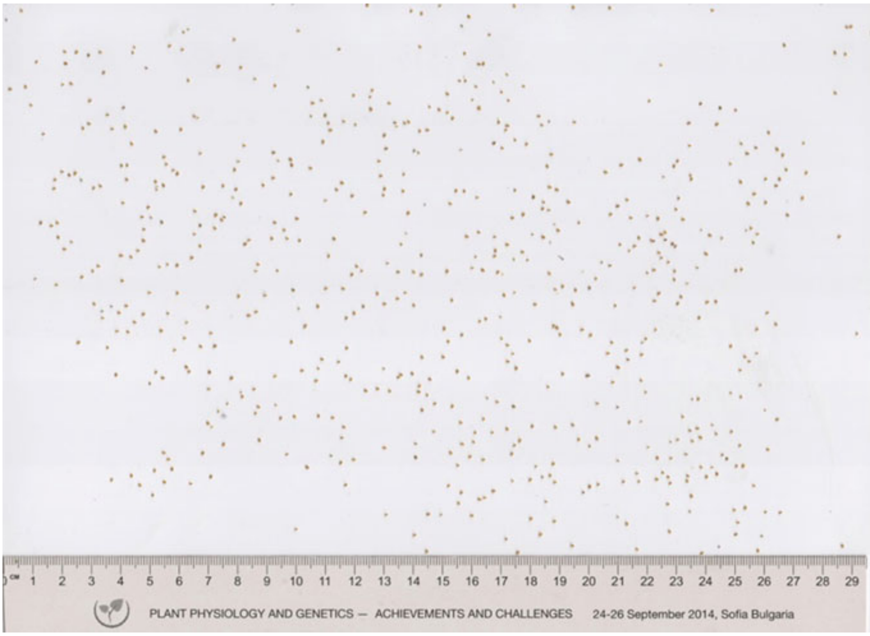

Fig. 3 The scanned image of small seeds of the perennial wall-rocket

Table 3 Linear parameters of the seeds the perennial wall-rocket of different

No.	Area, mm^2		Perimeter, mm		Length, mm		Width, mm	
	Average value	Conf. interval	Average value	Conf. interval	Average value	Conf. interval	Average value	Conf. interval
1	1.074	0.026	3.771	0.048	1.416	0.020	1.023	0.015
2	0.911	0.019	3.458	0.039	1.303	0.015	0.932	0.011
3	0.927	0.016	3.479	0.032	1.285	0.013	0.974	0.011
4	0.981	0.022	3.593	0.040	1.341	0.017	0.988	0.014
5	0.888	0.021	3.411	0.042	1.275	0.016	0.934	0.014

References

1. Abiduev, A.A.: Modeling the process of cleaning wheat seeds from hard-to-separate impurities. Vestnik East Siberian State Technol. Univ. **3**, 24–28 (2009)
2. ArgusSoft: The software official website. Retrieved from https://argussoft.org (2019)
3. Arkhipov, M.V., Pleidkin, N.S., Gusakova, L.P., Tyukalov, Yu.A., Perekopsky, A.N.: Introscopic express control of the integrity of the internal structures of the grain during the formation of production batches of grain, most suitable for long-term storage. Breed. Seed Prod. Genet. **2**(2), 52–54 (2015)
4. Arkhipov, M.V., Priyatkin, N.S., Zhuravleva, E.V.: A comprehensive approach to studies of the problem of inhomogeneity of seeds by biophysical methods. In: SIS XVIII: International

Scientific Congress, pp 19–20. Moscow, Russia (2014)
5. Demyanchuk, A., Grundas, S., Velikanov, L.: Identification of wheat morphotype and variety based on x-ray images of Kernels. Adv. Agrophys. Res. **10**, 223–267 (2013)
6. Kapadia, V.N., Sasidharan, N., Patil, K.: Seed image analysis and its application in seed science research. Adv. Biotechnol. Microbiol. **7**(2), 1–3 (2017)
7. Makrushin, N.M.: The Basics of Heterospermatology. Russia, Moscow (1989)
8. Musaev, F.B., Dobrutskaya, E.G., Kazydub, N.G., Skorina, V.V.: Assessing the environment of natural zones as a context for selecting the adaptability and propagation of vegetable bean seeds. Vegetable Crops Russ. (Ovoshi Rossii) **1**(18), 41–45 (2013)
9. Nielsen, M.S., Feidenhans'l, R., Damkjær, K.B.: Quantitative in-situ monitoring of germinating barley seeds using x-ray dark-field radiography. J. Food Eng. **198**, 98–104 (2017)
10. Sandeep Varma, V., Kanaka Durga, K., Keshavulu, K.: Seed image analysis: its applications in seed science research. Int. Res. J. Agric. Sci. **1**(2), 30–36 (2013)
11. Skorina, V.V., Musaev, F.B., Skorina, V.V., Pugachev, R.M.: Selection and Seed Production of Vegetable Beans. Belarusian Agricultural Academy, Gorki, Belarus (2015)
12. Tarasenko, A.P.: Reduction of Seed Injury During Harvesting and Post-harvest Processing. Voronezh State Agrarian University, Voronezh, Russia (2003)

Innovative Technologies in Flax Growing

Yuri T. Farinyuk, Anna G. Glebova, and Alexander S. Vasiliev

Abstract The objects of the research are the linen-flax of the Tverskaya variety, created by the Russian Scientific Research Institute of Flax (RSRIF), the peat reclamation agent Nisaba, which is the result of the work of specialists from the Tver State Technical University (TSTU) and the Tver State Agricultural Academy (TSAA), and the complexonates of trace metals first synthesized on the basis of the Tver State Agricultural Academy. The aim of the study is to develop a linen-flax fertilizer system based on the integrated use of peat ameliorant in combination with biological products, microelement complexonates, and tank mixtures of herbicides. In the framework of the stated topic of the research, the elements of the fertilizer system (based on the use of Nisaba peat reclamant) were developed using both in a separate form and a combination with new high-tech fertilizers and herbicides. The results of studying the effectiveness of using peat fertilizers on linen-flax show that the greatest influence on the increase in the yield of flax straw and flax seed is provided by the optimization of the humus state of the soil in combination with the satisfaction of plant needs for microelements. An effective way to solve this problem is the use of peat ameliorant in combination with various growth-regulating substances.

Keywords Linen-flax · Peat reclamant · Biological products · Complexonates · Tank herbicide blends

Y. T. Farinyuk · A. S. Vasiliev (✉)
Tver State Agricultural Academy, Tver, Russia
e-mail: vasilevtgsha@mail.ru

Y. T. Farinyuk
e-mail: ikc_tver@mail.ru

A. G. Glebova
Financial University under the Government of the Russian Federation, Moscow, Russia
e-mail: nauka_rf@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_63

1 Introduction

Growing linen-flax is a part of the traditional culture of the Tver region. From 2014 to 2018, Tver Oblast ranked first among the flax-growing regions of Russia in terms of the availability of cultivated areas of linen-flax. The largest sown area of linen-flax is concentrated in the Bezhetsky, Vyshnevolotsky, Kalyazinsky, and Staritsky districts. The flax complex of the region has rich production and scientific potential. New varieties of flax, technologies, and machines are being tested in the region, which allows flax growers to increase the yield of flax trusts. Nowadays, the use of innovation provides the main opportunity for the development of the industry and the region as a whole. Many foreign scholars [6, 9–12], as well as Russian ones [4, 5, 13], are interested in this issue.

Currently, in agriculture, innovation is the most in demand, giving not only an increase in the yield of cultivated crops but, at the same time, having a minimum level of costs for their implementation. It is for this reason that special attention in the flaxseed complex is given to the development and effective use of the fertilizer system for linen-flax based on the integrated use of the peat reclamation materials.

The fraction of humic substances of an acidic nature has received the general name 'humic acids,' which currently includes humic (HA), hematomelanic, and fulvic acids (FA). The following possible mechanisms of the influence of humic acids on plant growth and development are described in the scientific literature [1]:

- an increase in the amount of available iron due to the formation of iron-humus complexes;
- a change in the absorption of 2 and 3 valence cations (Ca^{2+}, Mg^{2+}, Fe^{3+}, Al^{3+});
- facilitation of ion exchange between protoplasm and soil solution;
- an effect on the viscosity and colloidal structure of protoplasm;
- an effect on the permeability of the cell membrane: in high concentrations, humic acids can damage the cell membrane;
- direct absorption of humic acids by cells; the FA can be absorbed to a greater extent than the HA;
- an interaction with enzymes: enzymes can integrate with the molecules of humus, giving them enzymatic activity; the FA in this regard is more active than the HA.

The application of humic fertilizers improves the physical, physicochemical properties of soil and its air, water, and thermal conditions. The humic substances, enveloping, glue mineral particles of soil together, thereby contributing to the creation of a water-resistant, lumpy, granular structure that improves the culvert, water-holding, and breathable soil [2, 7, 8].

The molecules of humates are included in the soil structure, the adsorbed forms of nutrients do not bind to the soil, are not washed out by water, and are in an accessible state for use by plants. Plants use these adsorbed substances more intensively than from the soil solution. The humic substances introduced into the soil contribute to the fixation of nutrients in it and their rational consumption.

Various properties of humic substances and their possibilities for application in agriculture are described [14].

The study allowed us to identify several basic schemes for the introduction of environmentally oriented agricultural systems in Russia:

1. The introduction of environmentally friendly agricultural systems on newly developed virgin and fallow land plots.
2. The introduction of modern biotechnology in farms engaged in traditional, essentially bio-organic but low-productive agricultural production (household plots, farms, etc.).
3. A complete rejection of the use of chemical fertilizers and pesticides in existing farms, their replacement with biological plant protection products, the widespread introduction of organic fertilizers, natural reclaimants, and energy- and resource-saving technologies:
   (a) immediately over the entire area of the agricultural enterprise;
   (b) stage-by-stage—on a certain fixed part (separation, crop rotation, land mass), followed by the introduction of environmentally oriented farming systems throughout the farm using the gained experience;
   (c) in a certain area of management (for example, feed production and animal husbandry, vegetable growing, etc.).
4. The gradual substitution of chemicals with biological products, agricultural techniques, and biotechnologies in various areas of activity throughout the whole or most of the farm.
5. The use of the peat mines for the cultivation of crops.

Peat fertilizers are of particular importance in connection with the adoption of the law "On Amendments to the Land Code of the Russian Federation and Certain Legislative Acts of the Russian Federation." According to this law, persons whose activities have led to a deterioration in the quality of land are required to ensure their restoration, which is a reduction of land in a condition suitable for use in accordance with the intended purpose and permitted use, including eliminating the consequences of the contamination of soils, restoration of their fertile layer, or, if such lands were conserved, to compensate their owners for losses. Peat fertilizers, in this case, are the least costly and shortest form of humus recovery.

2 Materials and Methods

During the growing season at the experimental site, the following observations and studies were regularly carried out in accordance with the "Methodological guidelines for conducting field experiments with linen-flax" (Methodical instructions, 1978):

- the phenological observations of plants;
- the determination of plant density;

- counting weediness;
- the determination of plant height;
- the assessment of individual indicators of photosynthetic activity;
- the determination of crop structure;
- crop accounting.

The studies were carried out in 2–3 factorial field experiments, in the experimental field of the Tver State Agricultural Academy on the cultivated sod-mid-podzolic residual carbonate gleyed soil on the moraine, sandy-grained by its granulometric composition. The agrochemical parameters of the soil are included: Nl.g.—70 mg/kg of the soil, labile phosphorus 269 mg/kg of the soil, exchange potassium 80–90 mg/kg of the soil, pH—6.0, Humus—1.8%.

The scheme of experiment No. 1. The following factors are studied in the experiment:

Factor A—the mineral nutrition background:

1. Without fertilizers (for effective fertility)
2. With the use of peat reclamant Nisaba (150 kg/ha).

Factor B—foliar nutrition of flax in the "herringbone" phase (100 l/ha):

1. Control—without fertilization
2. Azotovit 0.6 l/ha
3. Azotovit (0.3) + Phosphatovite (0.3). Total—0.6 l/ha.

Factor C—the use of a tank mixture of herbicides:

1. Hunter + Herbitox + Hrench (control)
2. Hunter + Herbitox + Secateurs Turbo
3. Hunter + Herbitox + Lontrel 300.

The scheme of experiment No. 1. The following factors are studied in the experiment:

Factor A—the background of mineral nutrition:

1. Without fertilization (for effective fertility)
2. With the use of peat reclamant Nisaba (150 kg/ha).

Factor B—the introduction of Azofoska:

1. Without Azofoska
2. With Azofoska (N96P96K96).

Factor C—fertilization with micronutrients in the herringbone phase.

1. Without fertilization
2. Seaweed complex
3. Seaweed zink

4. Selenium complexonate
5. Zinc complexonate
6. Boron complexonate
7. Boric acid solution.

The rate of flow of the working fluid for plants processing—200 l/ha.

The total area of the plot of the 1st order is 720 m^2, accounting—635 m^2; plots of the 2nd orders are—180 m^2, accounting—175 m^2; and plots of the 3rd orders are—20 m^2, accounting—18 m^2. Repetition—4 times, placement—randomized blocks. Linen-flax is rather responsive to changing growth conditions, caused by adjusting the supply of plants with mineral food through the use of peat reclamation, which is confirmed by the analysis of the density of seedlings. So, the increase in the field germination relative to the background of natural fertility in the context of options was 11.5%. This increase is due to the influence of the reclamation agent on the water-physical properties of the soil and the nutritional regime of plants, which, in total, enhances their vitality.

An increase in the yield of linen-flax from the applied elements of the cultivation technology contributed to the growth of the economic efficiency of the production of flax products (Table 1).

In the absence of foliar nutrition, the most appropriate variant was the use of a tanker mixture of herbicides Hunter + Herbitox + Secateurs Turbo, which provided ₽ 14.27 thousand/ha of conditionally net income with a profitability level of 59.0%, against a background of peat reclamation, which provided ₽ 15.96 thousand/ha of income with a profitability of 57.0%.

Spraying of bacterial fertilizers (as Azotovit and the mixture of Azotovit with Phosphatemia) is preferable to the Hunter + Erbitux + Lontrel 300 combination. This is based on the fact that the latter led to ₽ 19.81–21.82 thousand/ha of added income with profitability of 76.5–80.8%, while the former provided ₽ 21.81–24.53 thousand/ha with 70.7–80.5% profitability.

In general, the use of ameliorant increased profits by 22.0%.

A comparable regularity of the effect of peat reclamation was revealed in another experiment, where a top dressing with an azophos and various microelements was applied to the reclaim.

Promising forms of using trace elements characterized by high digestibility by plants include their complexonates. The particular effectiveness of their use is achieved due to the biological part (complexones) contained in them. The most effective and environmentally safe complexones for the creation of complexates are succinic acid derivatives, which include ethylenediamindiantaric acid (EDDAA), first synthesized at the Department of Chemistry of the Kalinin Agricultural Institute (now Tver State Agricultural Academy).

The production and chemical properties of the complexates of biometals are well studied, but at the same time, the feasibility and technology of the application of complexates of trace elements (B, Se, etc.) based on the EDDAA in the technologies of cultivation of various crops in the upper Volga region are insufficiently studied, which requires conducting special studies.

Table 1 Cost-effectiveness of cultivation of linen-flax, 2018

Background	Foliar nutrition	Herbicide Tank Mix	The cost of the crop, ₽ thousand/ha	Production costs, ₽ thousand/ha	Conditionally net income, ₽ thousand/ha	Profitability, %
Without fertilizer	Without nutrition	Hunter + Herbitox + Hrench (control)	24.27	22.82	1.45	6.4
		Hunter + Herbitox + Secateurs Turbo	38.46	24.19	14.27	59.0
		Hunter + Herbitox + Lontrel 300	31.47	24.24	7.23	29.8
	Azotovit	Hunter + Herbitox + Hrench (control)	30.75	24.59	6.16	25.1
		Hunter + Herbitox + Secateurs Turbo	43.89	25.99	17.90	68.9
		Hunter + Herbitox + Lontrel 300	45.69	25.88	19.81	76.5
	Azotovit + phosphatovit	Hunter + Herbitox + Hrench (control)	33.99	23.16	10.83	46.8
		Hunter + Herbitox + Turbo Secateurs	47.91	26.99	20.92	77.5
		Hunter + Herbitox + Lontrel 300	48.81	26.99	21.82	80.8
Peat Reclaiming Agent Nisaba (150 kg/ha)	Without nutrition	Hunter + Herbitox + Hrench (control)	38.79	28.31	10.48	37.0

(continued)

Table 1 (continued)

Background	Foliar nutrition	Herbicide Tank Mix	The cost of the crop, ₽ thousand/ha	Production costs, ₽ thousand/ha	Conditionally net income, ₽ thousand/ha	Profitability, %
		Hunter + Herbitox + Secateurs Turbo	43.98	28.02	15.96	57.0
		Hunter + Herbitox + Lontrel 300	39.15	28.59	10.56	36.9
	Azotovit	Hunter + Herbitox + Hrench (control)	42.84	29.14	13.70	47.0
		Hunter + Herbitox + Secateurs Turbo	49.77	30.30	19.47	64.3
		Hunter + Herbitox + Lontrel 300	54.99	30.46	24.53	80.5
	Nitrogenовит + phosphatovitis	Hunter + Herbitox + Hrench (control)	39.03	29.63	9.40	31.7
		Hunter + Herbitox + Secateurs Turbo	52.50	31.50	21.00	66.7
		Hunter + Herbitox + Lontrel 300	52.65	30.84	21.81	70.7

The experiment showed an increase in the yield of linen-flax when applying the studied micronutrient fertilizers. The economic feasibility of using the developed techniques is presented in Table 2.

The largest conditionally net income (₽ 20 thousand/ha) with a profitability level of about 70% was obtained on all backgrounds of mineral nutrition when fed with boron complexonate. The peat ameliorant increased profits when cultivating long flax by 3.0%, and the use of azofoska, as a rule, either did not practically change this indicator or reduce it due to the high cost of fertilizers.

Table 2 Cost-effectiveness of cultivating flax, 2018

Option			Crop value, ₽ thousand/ha	Production costs, ₽ thousand/ha	Conditionally net income, ₽ thousand/ha	Profitability, %
Without fertilizer	Without nutrition	No dressing	29.49	24.01	5.48	22.8
		Seaweed-Zinc	39.96	25.25	14.71	58.3
		Seaweed-Complex	41.25	25.61	15.64	61.1
		Se-EDDAA	40.53	25.39	15.14	59.6
		ZN-EDDAA	39.69	25.26	14.43	57.1
		B-EDDAA	46.35	26.02	20.33	78.1
		H_3BO_3	39.66	25.24	14.42	57.1
	Azofoska	No dressing	30.96	25.83	5.13	19.9
		Seaweed-Zinc	41.52	27.11	14.41	53.2
		Seaweed-Complex	42.81	27.47	15.34	55.8
		Se-EDDAA	43.26	27.27	15.99	58.6
		ZN-EDDAA	42.54	27.20	15.34	56.4
		B-EDDAA	47.94	27.90	20.04	71.8
		H_3BO_3	41.22	27.11	14.11	52.0
Peat Reclaiming Agent Nisaba (150 kg/ha)	Without nutrition	No dressing	33.06	27.72	5.34	19.3
		Seaweed-Zinc	43.62	29.00	14.62	50.4
		Seaweed-Complex	44.91	29.36	15.55	53.0
		Se-EDDAA	45.36	29.16	16.20	55.6
		ZN-EDDAA	44.64	26.44	18.20	68.8
		B-EDDAA	50.04	29.79	20.25	68.0
		H_3BO_3	43.32	28.99	14.33	49.4
	Azofoska	No dressing	34.92	29.17	5.75	19.7
		Seaweed-Zinc	45.12	30.55	14.57	47.7
		Seaweed-Complex	46.41	30.92	15.49	50.1
		Se-EDDAA	46.86	30.71	16.15	52.6
		ZN-EDDAA	46.14	30.64	15.50	50.6
		B-EDDAA	51.54	31.34	20.20	64.5
		H_3BO_3	44.82	30.55	14.27	46.7

3 Discussion

The integrated use of peat ameliorant on sod-mid-podzolic soils of the Central Non-Black Earth Region reveals its significance for long-flax productivity. Its application in pre-sowing treatment at a dose of 150 kg/ha increased the yield of flax seeds by 14.4% and that of flax straw by 19.7%, with an overall increase in flax yield of 22.0%.

Non-root fertilizers of flax seeds, with the bacterial fertilizer Azotovit, increased the productivity of the crop compared to its natural fertility—flaxseeds by 9.8–52.5%, straw by 21.7–36.4%; with a mixture of Azotovit and Phosphatovit—by 17.6–57, 5% and 47.4–59.3%; and compared to peat reclamation, 6.8–46.0, 4.5–39.5% and 8.5–36.0%, and 14.4–64.3% respectively.

The maximum yield of flax (seeds 5.1–5.9 kg/ha and straw 26.2–28.6 kg/ha) in the absence of foliar fertilizing was founded on both mineral nutrition and the introduction of a tank mixture of Hunter + Herbitox + Secateurs Turbo herbicides. Compared to the use of bacterial fertilizers, the tank mixture of Hunter + Herbitox + Lontrel 300 herbicides was preferable for the optimal ratio of flaxseed (6.1–7.3 c/ha) to straw (30.3–39.5 c/ha) production. The Hunter + Herbitox + Secateurs Turbo tank mixture had a predominant effect on the formation of flax straw yield, inferior to the mixture with Lontrel 300 in terms of the amount of flaxseed harvested.

An increase in the yield of linen-flax from the applied elements of the cultivation technology contributed to the growth of the economic efficiency of the production of flax products. In the absence of foliar top dressing, the most appropriate was the use of a tanker mixture of herbicides Hunter + Herbitox + Secateurs Turbo, which provided ₽ 14.27 thousand/ha of conditionally net income with a profitability level of 59.0% against a background of peat reclamation of ₽ 15.96 thousand/ha of income with a profitability of 57.0%.

Against the background of spraying the crops with bacterial fertilizers (both Azotovit and a mixture of Azotovit with Phosphatovit), it is more preferable to use Hunter + Herbitox + Lontrel 300, which, in terms of natural fertility, provides ₽ 19.81–21.82 thousand/ha of conditionally net income with a level profitability of 76.5–80.8%, and against the backdrop of ameliorant ₽ 21.81–24.53 thousand/ha from 70.7–80.5%, respectively.

The improvement of stem density and morphological parameters of linen-flax, caused by foliar fertilizing with trace element fertilizers, provided an increase in its productivity, increasing the yield of flax relative to wind crops by 2.9–9.4 c/ha (13.2–30.9%), and flaxseeds by 1.4–2.4 c/ha (34.9–41.9%) with a predominance in the formation of the yield of boron complexate.

4 Conclusion

When cultivating linen-flax on sod-mid-podzolic soils of the Central Non-Black Earth Region, in order to increase crop productivity and product quality, the following is recommended:

- to add peat reclamant at a dose of 150 kg/ha for pre-sowing soil cultivation with its obligatory subsequent incorporation into the soil;
- to carry out non-root nutrition of crops with Azotovit bacterial fertilizer in the herringbone phase of flax plants with a dose rate of 0.6 l/ha at a working fluid rate of 100 l/ha;
- to apply a tank mix of herbicides Hunter + Herbitox + Lontrel 300 in the herringbone phase of flax plants;
- to carry out the spraying of crops with boron complexon with a dose of 0.05 l/ha in the herringbone phase of linen-flax plants at a flow rate of 100–200 l/ha.

Acknowledgements The authors would like to express their gratitude to N. V. Grits, N. N. Ivanyutina, S. S. Skvortsov, A. Yu. Smirnov, V. P. Sutyagin, and P. N. Kuznetsov for the assistance in conducting this study.

References

1. Alexandrova, L.N.: Soil Organic Matter and its Transformation Processes. Science, Leningrad, USSR (1980)
2. Aristarchov, A.N.: The Optimization of Plant Nutrition and Fertilizer Application in Agroecosystems. Central Research Institute of Agrochemical Services, Moscow, Russia (2000)
3. Dolgov, B.S., Semenova, Z.M., Korolev, F.S. et al (eds.): Guidelines for Conducting Field Experiments with Flax Flax. Federal Research Center for Bast Crops, Torzhok, Russia (1978)
4. Farinyuk, Yu.T., Glebova, A.G.: The Creation of a Flax Cluster in the Tver Region. Federal Research Center for Bast Crops, Torzhok, Russia (2017)
5. Glebova, A.G., Lebedev, A.Yu.: The problem of activation of innovative processes in agriculture of the Tver region. Bull. Econ. Integr. **7**, 89–95 (2011)
6. Liu, C., Cutforth, H., Chai, Q., Gan, Y.: Farming tactics to reduce the carbon footprint of crop cultivation in semiarid areas. A review. Agron. Sustain. Dev. **36**, 69 (2016). https://doi.org/10.1007/s13593-016-0404-8
7. Mineev, V.G.: Agrochemistry. MSU Publishing House, KolosS Publishing House, Moscow, Russia (2004)
8. Mineev, V.G.: Topical problems of agricultural chemistry in modern agriculture. Probl. Agric. Chem. Ecol. **1**, 3–9 (2011)
9. Ricroch, A.: The evolution of agriculture and tools for plant innovation. In: Ricroch, A., Chopra, S., Fleischer, S. (eds.) Plant Biotechnology. Springer, Cham, Switzerland (2014)
10. Seufert, V., Ramankutty, N., Foley, J.A.: Comparing the yields of organic and conventional agriculture. Nature **485**, 229–232 (2012)
11. Singh, P.K.: Status paper on linseed/flax agriculture. In: Hegde, M., Zanwar, A., Adekar, S. (eds.) Omega-3 Fatty Acids. Springer, Cham, Switzerland (2016)
12. Tester, M., Langridge, P.: Breeding technologies to increase crop production in a changing world. Science **327**, 818 (2010)

13. Veselovsky, M.Y., Gnezdova, J.V., Glebova, A.G., Nikolskaya, V.A., Lebedev, A.Y.: Innovative transformation of the Russian industry in the framework of digital technologies. Espacios **39**(41), 35 (2018)
14. Voitovich, N.V., Andreev, S.S., Saffron, S.A.: The Range of Mineral Fertilizers and the Economic Efficiency of Their Application. Moscow Research Institute of Agriculture "Nemchinovka", Moscow, Russia (2005)

The Cost Planning and Cash Limits for Repair and Maintenance Work in the AIC

Natalya V. Sergeyeva

Abstract The effective functioning of the agro-industrial complex (AIC) mostly depends on the structure and size of the costs of the formation and operation of the engineering production base. In agriculture, the agronomic terms of technological operations, the complexity of production, the quality of the resulting product, and its cost depend on the state of the technical means. A significant share of the cost of agricultural products is the cost of operating machinery and equipment. The optimization of these costs is based on a rational distribution of repair and maintenance work between the levels of the repair base of the regional agro-industrial complex. The paper focuses on the methodology of cost planning and identifies the technologies for optimizing the distribution of repair work. The task of optimizing the distribution of repair and maintenance work, taking into account the specialization of the repair and maintenance base of the district, is to take down the total reduced costs by type of work. The objective function that allows solving the problem of optimizing the process of servicing equipment is proposed. The cost limits for the main types of repair and maintenance work are determined by the example of the economy of the Rostov region. The techniques for indexing costs in planning, which will more accurately reflect costs taking into account inflationary processes and other economic changes, are proposed. The distribution of the repair work by enterprises of various levels has been completed. The obtained results allow us to substantiate the production parameters and structure of the repair and maintenance facilities of a specific administrative region. The creation of information databases, scheduling, and aggregation of data flows for regulating end-to-end production processes on the current state of agricultural machinery, and upcoming periodic maintenance will increase the speed of response to failures and machine downtime, increase labor productivity, thereby becoming the basis for making operational decisions.

N. V. Sergeyeva (✉)
Russian State Agrarian University—Moscow Agricultural Academy named after K.A. Timiryazev, Moscow, Russia
e-mail: sergeewanv78@mail.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_64

Keywords Mechanized work · Maintenance works · Repair and maintenance base · Enterprises · Planning · Optimization · Infobases · Information and communication technology · Digital economy

1 Introduction

The effective functioning of the agro-industrial complex is a deliberate joint activity of agricultural producers, processing enterprises, organizations of engineering and technical maintenance of capital goods, and agricultural engineering on a mutually beneficial economic basis. A significant share (up to 18–20%) in the cost of agricultural products is made up of the costs of operating machinery and equipment, a large share of which is the cost of repair and maintenance work [6].

Timely and high-quality repair and maintenance work (RMW) requires providing agricultural enterprises of the agro-industrial complex (AIC) and their production divisions with the necessary production capacities of the repair and technical base (RTB). The cost of maintenance and repair is affected by the optimal distribution of maintenance work by type of repair base.

2 Materials and Methods

The rationale for the system should be based on the real volumes of repair and maintenance work and the optimization of their distribution between the levels of the repair base. The feasibility of optimizing the distribution of the RMW should be evaluated by the corresponding values of the criterion indicator (cost limit). When solving the organizational and economic problems, the minimization of the costs of maintaining and using the machine and tractor fleet (MTF) becomes such a factor. Comparing the total costs in the organization and the implementation of technological processes of maintenance and repair, we can determine their optimal value.

When determining the optimal system for maintenance and repair of equipment, the following initial information is required:

- the quantitative and brand composition of the fleet of machines used in the economy, the intensity of its use;
- the presence, condition, and location of objects of the repair-and-maintenance base and regional DTS;
- the provision of repair-and-maintenance units with repair-and-maintenance personnel.

The practice has shown that the following options for organizing the repair-and-maintenance work can be applied: by forces and means of agricultural enterprises in the conditions of a repair shop; repair with the participation of specialized repair-and-maintenance enterprises; repair with the participation of manufacturers (company service) [7].

Previously developed methods for substantiating a network of specialized enterprises for the repair of machinery and equipment formed the basis for using the appropriate optimization parameters.

The task of optimizing the distribution of repair-and-maintenance work while taking into account the specialization of the repair and maintenance base of the district involves distributing the work according to the RMW level. This method ensures a reduction in the total present costs, a lower capital investment for the construction and reconstruction of the base, fewer losses of the enterprise from equipment downtime for technical reasons, etc.[5].

The methodology is based on the economic and mathematical criterion for choosing a rational option for organizing the maintenance and repair of agricultural machinery [7].

The objective function of such a criterion will have the form:

$$\Pi_{\sum} = C_{\Pi} + C_{TP} + У + E_{H} K \rightarrow \min,$$

where Π_{Σ}—the total aggregate costs for maintenance and repair of machinery, ₽; C_{Π}—the production costs for maintenance and repair of machines, ₽; C_{TP}—the cost of transporting machines for maintenance and vice versa, ₽.; $У$—the product losses associated with the machine downtime for technical reasons, ₽.; E_H—the coefficient of the effectiveness of capital investments; K—the capital investments for construction or reconstruction of the repair and technical enterprise and acquisition of means of maintenance and repair, ₽.

It should be noted that with the increase in the capacity of the repair and maintenance enterprise, the service area also increases, which leads to an increase in transport costs associated with the delivery of objects to service and back.

The previous studies [7] of the dependence of the cost of maintenance and repair on production capacity and other factors show that with an increase in the concentration and specialization of work, conditions appear for reducing the cost of spare parts and repair materials, as well as for improving the quality of repair and maintenance work.

Given the coefficient that takes into account the reduction in the complexity (ϑ) of repair and maintenance actions for different options of technical service, the total costs will be:

$$\Pi_{\sum} = З_1 + \vartheta \cdot T_{ч} \cdot T_p \cdot K_{д} \cdot \eta_H + 2 \cdot T_{TP} \cdot l + Ц_n \cdot У_p \cdot \Pi_c \cdot K_n \cdot \\ \cdot \frac{T_{ф} - T_a}{T_{ф}} + E_H \cdot \vartheta \cdot \frac{C_{см} \cdot T_P}{T_Г} \rightarrow \min$$

The improvement of the efficiency of agricultural production, the reduction of the production costs, the creation of new science-intensive industries, the involvement of new professions in agricultural production, increasing rural incomes, and increasing agricultural exports are the stated objectives of the Digital Agriculture program [1].

Russia has a significant reserve for increasing the efficiency of the agricultural production (3–5 times) due to the introduction of digital processes and technologies in crop production, livestock breeding, in repair and maintenance units, and increased labor productivity and full use of the capabilities of modern digital platforms for managing on macro and local production levels.

The creation of information databases, scheduling, and aggregation of data flows for regulating end-to-end production processes on the current state of agricultural machinery and upcoming periodic maintenance will increase the speed of response to failures and machine downtime, increase labor productivity, and thereby become the basis for making operational decisions.

The large-scale introduction of innovative technologies is the basis of the competitiveness of Russian products in the domestic and foreign markets. Information and communication technologies in agriculture are one of the innovative directions of introducing the principles of the digital economy in the agricultural sector, which Russia has yet to master. Today, the digital economy in agriculture is no longer just words, many farms are mastering remote electronic metering technologies, but a system for collecting and processing information from chips has not yet been fully launched. These technologies, first of all, should bring domestic farmers a sharp increase in business efficiency.

It is now necessary to develop and install local and global information technologies based on accounting platforms, for example, the IoT platform. Huawei's *OceanConnect IoT platform* provides sensor management and hosts the *Holmer application*, which provides the collection, processing, analysis, and display of real-time data on the status of equipment in the machine yard and operation. Huawei also has a new *X Labs* information and analytics platform for innovating in various industries.

IoT platforms will automate the monitoring of vehicles and agricultural machinery, their seasonal loading of operations, equipment operating modes, technical condition, quality of the performed repair work, and much more.

In order to formalize the problem under consideration and address it using a computer program, it is necessary to introduce all the components with an indication of the range of possible values into the structure of the economic-mathematical model and software [7].

The annual volume of maintenance and repair work on tractors and combines is determined on the basis of the annual volume of mechanized work on the farm, the established frequency (time) of a specific type of service, and standard labor [6]. Mechanized work volume for tractors is determined on the basis of brands and models of equipment.

The number of scheduled tractor repairs and maintenance is determined on the basis of the planned volume of mechanized work for each brand of tractor [4].

The total norm and the cost structure in ₽ per conditional hectare for capital repairs, maintenance, transport service, and storage, as well as indexing coefficients, are determined according to the following formula by the current standard for technical service costs (H_m) [7]:

$$H_m = 0{,}01 \cdot H_o \cdot \left(K_{KP} \cdot C_{KP} + K_{TP} \cdot C_{TP} + K_{TO} \cdot C_{TO} + K_X \cdot C_X\right),$$

where H_o—the current standard of costs for technical service, ₽/conditional reference hectare; K_{KP}, K_{TP}, K_{TO}, K_X—coefficients of indexation of costs, respectively, for the overhaul, maintenance, transport service and storage; C_{KP}, C_{TP}, C_{TO}, C_X—the percentage cost structure, respectively, the overhaul, maintenance, car service, and storage.

The coefficient of cost indexation for spare parts is determined depending on the change in the price level of agricultural machinery at the time of planning, to the level of prices at the beginning of the year, taken as the base.

With an increase or decrease in average annual production per one reference tractor or combine harvester, the costs of maintenance, repair, and storage also change accordingly. The previously developed standards for technical service costs were planned for the average annual output of tractors and combiners equal or close to the normative [2]. At present, the annual output of machines and machine-tractor aggregates differs significantly from that previously adopted as normative. Thus, for example, in the AIC, according to the survey results, the production of a reference tractor varies from 450 to 800 conditional units of a hectare, for the combine harvesters, Don-1500—250–450 ha of harvested area. Therefore, when planning the cost of funds for technical service, it is necessary to take into account the coefficient of the intensity of machine use [4].

Depending on the form of payment for the purchase of machines and spare parts (prepayment, payment upon receipt or after, payment in cash), manufacturers also set trade discounts up to 25% of the original price.

The new dealer policy of most equipment manufacturers provides substantial discounts for their official dealers when they purchase large batches of cars. Depending on the size of the lot, these discounts can range from 10 to 30%. Rural producers (the main consumers of agricultural machinery and spare parts for it), being in the difficult financial situation of recent years, do not have the opportunity to purchase them in such large batches.

3 Results

We will consider the methodology for cash planning using the example of the central repair shop of the agricultural company “Aksayskoye CJSC” in the Rostov region when servicing a tractor fleet and harvesting equipment. The initial data for the performance of the work will be the brand and quantity of the tractors and combine harvesters, the planned volumes of mechanized work, standards, and the cost structure of funds.

Based on the equipment tests performed in the Rostov region, the standards for hourly operating costs are determined as the initial ones; knowing the operating performance of tractors (combiners) and the planned volumes of mechanized work, we can determine the total costs of maintenance and repair of the equipment (Table 1).

Table 1 The presence of tractors and the volume of work performed by them

Brands of tractors	Quantity, pcs	Hourly operating costs, ₽/h	Operational performance, ha per conditional reference ha. (physical ha, thousand km)/h	The planned volume of mechanized work, conditional reference, ha (physical ha, thousand km)	Total costs for maintenance and repair, ₽
Tractors (conditional reference ha)					
K-744	1	1344.3	2.79	1066	236,269
RT-M-160	2	1160.8	2.23	1852	443,457
"Belarus-1523"	3	1061.3	1.90	2086	536,041
HTA-200–10	1	1267.9	3.14	749	139,122
"Claas Axion 850"	3	1876.4	3.86	2679	599,057
"ATM 4200 Terrion"	2	1528.5	4.70	948	141,819
ATM 7360	1	2674.0	10.81	344	39,143
Total	13			9724	2,134,908
Harvesters (phys. ha)					
"Torum 740"	2	5753	4.6	1026	538,930
"Tucano 340" Claas	2	5760	2.31	834	873,423
"Vektor 410"	2	2867	3.62	1090	362,571
"Acros 580"	2	3836	3.82	1320	556,721
"Jaguar 850"	1	6023	2.87	434	382,533
Total	9				2,714,178
Cars (thousand km)					
KamAZ-5320	2	1754	0.034	4692	130,708
ZIL-MMZ-545	3	1496	0.039	6168	127,762
GAZ-53	2	826	0.046	7756	75,206
GAZ-3109	2	721	0.058	5646	37,900
Total	9				251,576

Hourly operating costs were obtained according to the Federal State Budgetary Institution Rosinformagroteh as a result of equipment testing in the Rostov region [3].

The total costs of maintenance, repair, and storage are determined on the basis of their share in operating costs. For tractors, it is 46%, for combiners 42%, and for cars 54%.

Cost planning for maintenance, repair, and storage of the machinery fleet is carried out on the basis of cost standards and the volume of mechanized work (Table 2). The annual limit of cash costs for maintaining a fleet of agricultural machinery for farms in the Rostov region is 52% of the total costs for maintaining a fleet of tractors.

Having received the amount of cash costs for maintenance, repair, and storage of machines, and knowing the structure of cash costs (Table 3) by types of repair and maintenance impacts and cost items, we can limit the costs of spare parts, materials, labor, and other expenses. Labor costs include the basic and additional (bonus part) wages of workers and deductions for social needs.

The received amounts of cash costs by types of services and items of expenditures are summed up, forming the total limits of cash costs of the economy (Table 4).

In addition to paying for providing a given level of the coefficient of technical readiness, the CRM team carries out overhaul and specialized repair work on the current car repair, as well as specialized repair work for agricultural and other machinery, combiners, and equipment for animal husbandry. For the volume of work

Table 2 The norms of cash costs for maintenance and repair of machines by the type of work

Types and brands of the machines	Normative ₽/unit of work	Structure, %			
		Overhaul	Running repairs	Transport service	Storage
Tractors (conditional reference ha)					
K-744	415	24	46	23	7
RT-M-160	392	25	47	22	6
“Belarus-1523”	334	18	47	26	9
HTA-200–10	284	21	49	20	10
“Claas Axion 850”	267	20	49	21	10
“ATM 4200 Terrion”	219	25	47	22	6
ATM 7360	256	20	47	23	10
Harvesters (phys. ha)					
“Torum 740”	698	24	46	13	17
“Tucano 340” Claas	806	25	47	12	16
“Vektor 410”	552	26	48	15	11
“Acros 580”	628	23	50	12	15
“Jaguar 850”	932	25	47	12	16
Cars (thousand km)					
KamAZ-5320	737	28	49	23	–
ZIL-MMZ-545	622	25	51	24	–
GAZ-53	510	24	53	23	–
GAZ-3109	421	25	55	20	–

Table 3 The cost structure of funds for maintenance and repair of machinery by cost items

Brands of cars and types of work	Spare parts	Materials, fuel, and lubricants	Salary	Other (general production)
Tracked tractors				
Overhaul	60	6	18	16
Running repairs	63	6	16	15
Maintenance	30	12	26	32
Energy-saturated wheeled tractors				
Overhaul	58	8	16	18
Running repairs	50	9	12	29
Maintenance	30	18	30	22
Other tractors				
Overhaul	52	7	14	27
Running repairs	48	8	19	25
Maintenance	45	15	20	20
Combine harvesters				
Overhaul	62	5	18	15
Running repairs	57	6	16	21
Maintenance	36	20	20	24
Forage harvesters				
Overhaul	62	5	14	19
Running repairs	56	5	17	22
Maintenance	28	18	30	24
Trucks				
Overhaul	52	8	12	28
Running repairs	57	6	14	23
Maintenance	24	19	26	31

performed on these machines, production units are calculated by check, with a part of the received amount (approximately 12–20%) sent to the wage fund.

Similarly, the annual cost limits are determined for maintenance, repair, and storage, as well as for combiners, cars, and agricultural machines.

The rational distribution of the total volume of work in percentage among workshops of various levels of RMW depends on the availability of these facilities, the condition and remoteness from farms, and the composition of the machine and tractor fleet, taking into account the service life of the machines and the volume and complexity of the repair and maintenance work.

The optimal values of the objective function obtained using the economic and mathematical model make it possible to distribute the types and volumes of repair and maintenance work performed in the conditions of farm repair workshops and with the involvement of local repair and technical bases.

Table 4 The annual limit of costs for maintenance, repair, and storage of tractors on the farm

Brands of tractors	The annual limit of costs for maintenance, ₽	Overhaul, ₽	Including			
			Spare parts	Materials, fuel, and lubricants	Salary	Overhead costs
К-744	236,269	56,705	32,889	4536	9073	10,207
RT-M-160	443,457	110,864	57,649	7761	15,521	29,933
"Belarus-1523"	536,041	96,488	50,174	6754	13,508	26,052
HTA-200–10	139,122	29,216	15,192	2045	4090	7889
"Claas Axion 850"	599,057	119,811	62,302	8387	16,774	32,348
"ATM 4200 Terrion"	141,819	35,455	18,437	2482	4964	9572
ATM 7360	39,143	7829	4541	626	1253	1409
Total	2,134,908	456,368	241,184	32,591	65,183	117,410

Table 5 The distribution of repair and maintenance work for tractors between the central repair and technical bases of farms and RTB, %

Types of work	Central repair and technical bases	RTB
Major repair	45.2	54.8
TPp	63.2	36.8
Tnp I	100	0
II	100	0
III	75.2	24.8
Technical maintenance No. 1	100	0
Technical maintenance No. 2	100	0
Technical maintenance No. 3 (auto workshop)	93.3	6.7

The results of the distribution as a percentage of the types of repair and maintenance work among the farm workshops and in the conditions of existing RTB are summarized in Table 5.

4 Conclusion

Having received the amount of money spent on the maintenance, repair, and storage of the leading brands of tractors (К-744, RT-M-160, Belarus-1523, XTA-200–10, Claas Axion 850, ATM 4200 Terrion, ATM 7360), combiners (Torum 740, Tucano

340 Klaas, Vektor 410, Acros 580, Jaguar 850), and cars (KamAZ-5320, ZIL-MMZ-545, GAZ-53, GAZ-3109) used in the farms of the Rostov region, and knowing the structure of the cost of cash in the expense items, limits on the cost of spare parts, materials, labor, and other expenses are defined.

Considering the obtained data and using the program for optimizing the distribution of repair and maintenance work, we can conclude that for small farms with an area of up to two thousand hectares, the most efficient (at the lowest cost) will be the distribution of work in the central distribution centers of farms: 59%, and 41% with rational involvement of the Central TP; for medium-sized farms: 81% and 19%, respectively; for large farms with an area of 4000 ha or more, the distribution will be 91% and 9%, respectively.

The obtained results make it possible to justify the production parameters and structure of the repair and maintenance facilities of a specific administrative region.

References

1. Bogoviz, A.V., Taranov, P.M., Shuvaev, A.V.: Innovational tools for provision of food security through state support for the agro-industrial complex in the conditions of digital economy. Adv. Intell. Syst. Comput. **622**, 659–665 (2018)
2. Bogoviz, A.V., Bugai, Y.A., Minenko, A.V.: Economic analysis of effectiveness of the existing tools of state support for entrepreneurship in the AIC in the digital economy. Lecture Notes in Networks and Systems, vol. 57, pp. 789–794 (2019)
3. Burak, P.I., Pronin, V.M., Prokopenko, V.A., Medvedev, A.A., Mikaya, T.B., Kiselev, S.N., Zherdev, M.N., Zhidkov, G.A., Maslovsky, V.I., Konyukhov, L.V., Kolodin, L.V., Dobrynin, Y.M., Ishkin, P.A., Pronin, V.V., Mikhailov, V.A., Belyaev, O.M., Komarov, S.A., Fedorenko, V.F.: Comparative tests of agricultural machinery. Rosinformagroteh, Moscow, Russia (2014)
4. Kushnarev, L.I.: Design and organization of the use of machinery at agricultural enterprises. Aktualnyye Agrosistemy **9**, 12–14 (2017)
5. Kushnarev, L.I., Sergeeva, N.V.: Organizational and economic foundations of rational maintenance and repair of equipment. Bulletin of the Federal State Educational Institution of Higher Professional Education "Moscow State Agroengineering University named after V.P. Goryachkin" **1**(6), 37 (2004)
6. Sergeeva, N.V.: Why the effectiveness of ICC on the fields of Russia is low. Selskiy Mechanizator **3**, 44–45 (2008)
7. Sergeeva, N.V.: Improving the organization of technical service of domestic agricultural machinery. LLC "UMTS Triada", Moscow, Russia (2015)

Innovative Development in Agriculture

Vasily I. Nechaev

Abstract Innovative development is based on knowledge and innovation. The paper focuses on the assessment of the innovative development of agriculture and its main sectors. It is concluded that there is insufficient funding for agricultural science and the low level of domestic innovation. The introduction of innovations during the construction, reconstruction, and modernization of agricultural enterprises and farms is characterized by low returns per an object (except for poultry farming), which is explained by the length of the production cycle in beef cattle breeding and the period of reaching its design capacity. Regions with a large share of agricultural production in gross regional product have a lower level of innovative development, which requires increased funding for agricultural science and the active introduction of innovations in production.

Keywords Agriculture · Development · Innovations · Industries

1 Introduction

The role and place of agriculture in the country's economy is determined by a specific weight of its share in gross domestic product (about 4% in 2017), the commodity structure of exports (5%), the high cost of food products in household expenses (more than 30%), and the significance in the development and conservation of rural areas.

During the development of agriculture in Russia, we can distinguish alternating periods of growth and decline due to socio-economic and weather factors. Against the backdrop of the stagnation of the economy as a whole, modern agriculture demonstrates relatively high growth rates of production, accompanied by a decrease in soil fertility, a deterioration in the state of social infrastructures, and a deep differentiation of agricultural producers in terms of profitability, material, and technical support, which reduces the sustainability of development.

V. I. Nechaev (✉)
Federal Research Center of Agrarian Economy and Social Development of Rural-Areas—All Russian Research Institute of Agricultural Economics, Moscow, Russia
e-mail: vin981@yandex.ru

A. V. Bogoviz (ed.), *Complex Systems: Innovation and Sustainability in the Digital Age*, Studies in Systems, Decision and Control 282,
https://doi.org/10.1007/978-3-030-44703-8_65

The State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets defines the goals, objectives, and main directions of development of the industry, its financial support, mechanisms for the implementation of the measures, and performance indicators. In 2018, the amount of funds allocated for the implementation of the measures of the State Agro-Industrial Complex Development Program was increased to ₽ 303.6 billion against ₽ 254.1 billion in 2017.

In the development of agricultural sub-sectors, one can note the active development of pig farming (up to 5%) due to the completion of investment projects and their achievement of design capacity; access to foreign markets, development of Asian directions (China, Korea, Japan) by poultry farming, supply of beef to China and Turkey; the growth of vegetables grown in closed ground, mushrooms, fruit, and berry products due to the introduction of greenhouses and the laying of gardens; an increase in the share of domestic products in trade due to the commissioning of fruit, vegetable, and potato storages with state support for their construction, reduction of price volatility in the fruit and vegetable market.

One of the goals of agricultural development, determined by the May Decree of the President of the Russian Federation "On National Goals and Strategic Tasks of the Development of the Russian Federation for the period until 2024," is to create a highly productive export-oriented sector in the agro-industrial complex with an increase in exports by 2024 to $45 billion, which requires solving a set of tasks related to the development of high-tech production of agri-food products.

2 Materials and Methods

The study used economic and statistical research methods. Materials from Rosstat and the Ministry of Agriculture of Russia were used as initial data.

3 Results

The implementation of the innovative model for the development of agriculture in Russia presupposes a systematic integration of the scientific and technical sphere in the development of agriculture, which requires a steady flow of effective innovations in agricultural production.

Innovation activity is a set of scientific, technological, organizational, financial, and commercial activities leading to innovation.

Rosstat began to evaluate innovative development in agriculture starting in 2016; therefore, indicators can so far be presented only for one year.

The generally accepted innovative development of agriculture is considered in three main areas [7]: the human factor—the priority development of education and research; the biological factor—the development of innovations in the field of increasing soil fertility, crop productivity, and productivity of farm animals; technological factor—the use of energy and resource-saving equipment and high technology, technological modernization of the agricultural sector.

As can be seen from the presented data Table 1, the proportion of organizations implementing innovations of individual types is 4%, there prevails the technological direction of innovative development. Marketing innovations are applied in the smallest volume (0.4%), which is explained by the weaker position of agricultural producers in the marketing system and the inability to fully implement the marketing mix—the inability to dictate agricultural prices to the market and implement their own pricing strategies. Organizational innovations are also insignificant (0.9%), due to the completion of institutional reforms in the industry.

Table 1 Innovative activity of agricultural organizations, 2016

	Proportion of organizations implementing innovations of certain types, in the total number of organizations examined, %			
	Total	Technological	Marketing	Organizational
Total crop production, animal husbandry, crop production in combination with animal husbandry (mixed agriculture), provision of services in the field of crop production, ornamental horticulture and animal husbandry, except veterinary services	4.0	3.4	0.4	0.9
Crop production	4.2	3.7	0.2	0.8
Animal husbandry	4.7	3.9	0.7	1.1
Crop production in combination with animal husbandry (mixed agriculture)	2.7	1.8	–	0.9
Provision of services in the field of crop production, ornamental horticulture and animal husbandry, except veterinary services	1.8	1.5	0.1	0.4

Source Compiled by the authors based on the Rosstat data [6]

By the type of activity Table 1, the share of innovatively active agricultural organizations is higher in specialized organizations, mainly in livestock breeding (4.7%), and the return on this industry is higher—₽ 2.61 in the volume of innovative products per ₽ 1 of costs of technological innovations Table 2, which is achieved due to state support of priority sectors of livestock—poultry, pig, beef, and cattle.

For the analyzed period (2013–2017) Table 3, the largest increase in the number of newly built and modernized farms is observed in beef cattle breeding (130.77%). However, the largest return in the form of the share of additional production per one object is higher in poultry farming (0.14%), which is explained by the duration of the production cycle in beef cattle breeding and relatively lower cost recovery.

Large integrated groups, receiving a greater share of state support, are modernizing along the entire technological chain, which allows improving the quality and assortment of meat products supplied for sale to retail chains.

Most of the technologies for agriculture are purchased abroad Table 4. The number of agreements on technology imports exceeds their export in the type of activity "agriculture, forestry, hunting, fishing, and fish farming" (3.64 times higher), their cost is 1.68 times higher. Moreover, in comparison with other sectors, the purchase of technologies by type of activity, such as "agriculture, forestry, hunting, fishing, and fish farming," does not amount even to 1% in all indicators in the economy. At the same time, the ratio of the cost of imported and export technologies for this type of activity (1.68) is 2.5 times higher than in the economy as a whole (0.67).

In the regional aspect, we will consider the relationship between the level of agricultural development and the level of innovative development on the basis of grouping data on Russian regions by three indicators: the share of agriculture in GRP, the index of scientific and technological development, and the level of intensity of R&D expenses Table 5.

The data in Table 5 indicate that the index of the scientific and technological region, and the intensity of research and development costs increase with a decrease in the share of agricultural production. At the same time, for the first group of regions, the index of scientific and technological development is below the average by 14%, and the indicator of the intensity of R&D costs is 41.6%, which confirms the need to increase the cost of agricultural science in order to enhance the innovative development of the industry.

4 Discussion

The study revealed the main trends in the innovative development of agriculture:

- underfunding of agricultural science, affecting the innovative development of the industry and regions;
- low level of return in the form of the share of additional agricultural products per one constructed, reconstructed, or modernized facility with the introduction of a certain level of innovation (except for poultry farming—0.14%);

Table 2 The volume of innovative products and the costs of technological innovation in agricultural organizations, 2016

	Costs of technological innovation, ₽ billion	Proportion of technological innovation costs in the total volume of shipped goods, performed work, and provided services, %	Volume of innovative goods, works, and services, ₽ billion	As a percentage of the total volume of shipped goods, performed work, and provided services	Volume of innovative goods, works, and services per ₽ 1 of costs, ₽/₽
Total crop production, animal husbandry, crop production in combination with animal husbandry (mixed agriculture), provision of services in the field of crop production, ornamental horticulture and animal husbandry, except veterinary services	15.0	0.9	22.2	1.4	1.48
Crop production	6.3	1.1	6.5	1.1	1.03
Animal husbandry	5.7	0.6	14.9	1.6	2.61
Crop production in combination with animal husbandry (mixed agriculture)	2.9	5.7	0.6	1.2	0.21
Provision of services in the field of crop production, ornamental horticulture and animal husbandry, except veterinary services	0.1	0.7	0.1	0.7	1

Source Compiled by the authors based on the Rosstat data [6]

Table 3 An increase in agricultural production due to innovations applied in newly built, reconstructed, and modernized enterprises and farms

	Years					Total for 2013–2017	On average	2017–2013, %	The share of additional production per 1 facility, %
	2013	2014	2015	2016	2017				
The number of pig enterprises and farms	39	37	30	38	40	184	36.8	102.5	–
The share of additional production in the total production of pigs for slaughter (in live weight), %	4	4	2	3.2	1	14.2	2.84	−3	0.08
The number of poultry enterprises and farms	31	30	26	20	32	139	27.8	103.2	–
The share of additional production in the total poultry production for slaughter (in live weight), %	3	3.5	3.9	4.1	4.8	19.3	3.86	1.8	0.14
The number of cattle farms	65	65	107	61	85	383	76.6	130.7	–
The share of additional production in the total production of cattle for slaughter (in live weight), %	0.12	0.29	14.5	2.1	1.4	18.41	3.68	1.2	0.05

Source Compiled by the authors based on the National report [5]

Table 4 Technology trade with foreign countries under agreements in 2017

	Export			Import			The ratio of imports to exports, times		
	Number of agreements	Cost of the subject of the agreement, million USD	Revenue for the year, million USD	Number of agreements	Cost of the subject of the agreement, million USD	Revenue for the year, million USD	Number of agreements	Cost of the subject of the agreement, million USD	Revenue for the year, million USD
Total	2757	26,416	1181	4358	17,676	3305	1.58	0.67	2.80
Including agriculture, forestry, hunting, fishing, and fish farming	11	1.9	1.8	40	3.2	2.3	3.64	1.68	1.28
Same, in % to the total	0.399	0.007	0.152	0.918	0.018	0.070	0.399	0.007	0.152

Source Compiled by the authors

Table 5 The distribution of regions depending on the innovativeness of agricultural development

A group on the proportion of agriculture in the region's GRP	The number of regions in the group	The share of agriculture in the region's GRP	R&D Cost Intensity	Scientific and technological development index, points
Group 1, above the national average	31	0.16	0.45	30.66
Group 2, below the national average	51	0.05	0.96	38.78
Average	82	0.09	0.77	35.68

Source Compiled by the authors based on the Rosstat data and the Rating of Scientific and Technological Development of the Constituent Entities of the Russian Federation [4, 6]

- a priority for the purchase of imported technologies (less than 1% for all indicators in the economy), when their value is 2.5 times higher, the lower the level of implementation of domestic scientific developments and technologies.

5 Conclusion

For the further innovative development of the agro-industrial complex, it is advisable to modernize it on the basis of product and technological innovations, including the predominant implementation of domestic scientific developments.

References

1. Ministry of Agriculture of the Russian Federation: Final report on the results of the activities of the Ministry of Agriculture of Russia for 2018. Moscow, Russia. Retrieved from https://docviewer.yandex.ru/view/50546582 (2019)
2. Ministry of Agriculture of the Russian Federation: State program for the development of agriculture and regulation of agricultural products, raw materials and food markets for 2013–2020. Moscow, Russia. Retrieved from https://mcx.ru/activity/state-support/programs/program-2013-2020/ (n.d.)
3. President of the Russian Federation: The decree "On national goals and strategic objectives of the development of the Russian Federation for the period until 2024". Retrieved from https://www.consultant.ru/document/cons_doc_LAW_297432/ (2018)
4. RiaRating: Rating of scientific and technological development of the constituent entities of the Russian Federation. Retrieved from https://riarating.ru/infografika/20161020/630044781.html (2016)

5. Rosinformagroteh: National report “On the progress and results of the implementation in 2017 of the State Program for the Development of Agriculture and Regulation of Agricultural Products, Raw Materials, and Food Markets for 2013–2020”. Russia, Moscow (2018)
6. Rosstat: Russia in Numbers, 2018. Brief Statistical Compilation. Russia, Moscow (2018)
7. Sandu, I.S., Nechaev, V.I., Ryzhenkova, N.E.: Priority Directions for the Innovative Development of the Agro-Industrial Complex in Modern Russia: Methodological Approaches. Nauchnyy konsultant, Moscow, Russia (2017)