Edited by
Elena B. Zavyalova · Elena G. Popkova

Industry 4.0

Fighting Climate Change in the Economy of the Future

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Preface

Climate change is one of the main threats to human survival, which is especially urgent today. Throughout the thousands of years of human history, the state of the environment has defied either its monitoring or its management. In the twentieth century, against the backdrop of powerful and widespread industrialization and urbanization, climate change began to accelerate. However, until recently, climate change remained a phantom threat, recognized only in the academic environment but not in the general population, business, and government world.

Through media coverage of environmental issues, a progressive and responsible global society has emerged that has opened its eyes to climate change, ready for multilateral dialogue and solving environmental problems. The COVID-19 pandemic has been a long-awaited signal for the global community to heed environmental issues and rally for solving them. The interests of saving lives came first and overshadowed the interests of the Consumer Society.

The Fourth Industrial Revolution and the transition to Industry 4.0 deserve a controversial interpretation from the standpoint of the impact on climate change. The negative impact is associated with an increase in production capacity and the acceleration of digital economic growth, increasing the negative anthropogenic influence on the environment. Automation and technocratization lead to a critical increase in energy consumption. The information society is not ready to give up the usual benefits for the sake of saving nature, at least at the current stage of its development.

The positive impact is that high technologies today allow large-scale monitoring of climate change at the level of individual territories and the global economy using “smart” systems and frameworks. Industry 4.0 technologies are also helping to reduce the dependence of economic activities on the state of the environment, a prime example of which are autonomous and “smart” vertical farms.

This contradiction has yet to be resolved by humanity in the coming years. Industry 4.0 will still show itself—either by causing a global environmental crisis or by overcoming it with the help of technological support for responsible production and consumption. What choices humanity will make, science cannot predict but it can predict the likely consequences of each of the available alternatives for the development of Industry 4.0 and offer promising solutions for using the capabilities of Industry 4.0 to combat climate change.

This book, presented in two volumes, is devoted to these questions. The first volume reflects the impact of *Industry 4.0* on climate change. The second volume presents a scientific vision of the prospects for combating climate change in the economy of the future based on *Industry 4.0*. The book has a broad scope of the readership, including not only academic scientists studying the issues of Industry 4.0 and climate change but also business entities making decisions on using the opportunities of Industry 4.0, taking into account the problems of climate change, as well as public administration bodies at the level of territories, countries and the global economy, regulating the transition to Industry 4.0 and the fight against climate change.

Moscow, Russia Elena B. Zavyalova

A Systemic Vision for Climate Change Combating in the Future Economy in Industry 4.0: Introduction

Despite the COVID-19 pandemic, the global fight against climate change must resume as soon as possible. In this volume, we assume and substantiate that, in the economy of the future, Industry 4.0 can transform from a barrier to a mechanism of combating climate change. However, when implementing fragmented "green" digital initiatives, the effect on environmental protection will be weak or even zero and, therefore, a systematic vision of combating climate change in the economy of the future in the context of Industry 4.0 is needed to implement the coordinated efforts.

The government must head the fight against climate change by developing a regulatory framework that creates effective regulatory and market incentives for creating responsible industries in Industry 4.0. It should be complemented by a corporate fight against climate change in Industry 4.0 sustainable entrepreneurship, willing and inclined to assume the responsibilities, risks, and financial burdens of placing "green" investments in Industry 4.0.

The fight against climate change should be carried out at the level of the territories, which will have to determine their guidelines for environmentally friendly digital development. In the context of the economy, industry specificity should be taken into account and special industry initiatives should be implemented to combat climate change based on the capabilities of Industry 4.0. This is especially important in industrial sectors with the highest environmental costs and threats. Also, digital technologies should be created and spread for various areas of economic activity, including responsible consumption, allowing conducting a multidirectional fight against climate change based on the capabilities of Industry 4.0.

This second volume of the book *Industry 4.0: Fighting Climate Change in the Economy of the Future* aims to provide a designated vision for climate change in the future economy of Industry 4.0 and is dedicated to identifying perspectives and developing recommendations for using the capabilities of Industry 4.0 for combating climate change in the future economy. It is divided into five parts, the first of which focuses on the regulatory framework for combating climate change in the future economy in the context of Industry 4.0.

The second part highlights the corporate combating against climate change in the economy of the future based on the capabilities of Industry 4.0. The third part reflects the prospects for climate change combating in the economy of the future in the context of Industry 4.0 at the territorial level. The fourth part reveals the industry specifics and opportunities to combat climate change in the economy of the future in the context of Industry 4.0. The fifth and final part outlined digital technologies to climate change combating in the economy of the future through Industry 4.0.

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The winner of various competitions: the winner of the A. N. Kosukhin Prize for 2000 in the category "For the best scientific publication" for the monograph "Sociological diagnostics of the ethnocultural situation"; the winner of the A. N. Kosukhin Prize for 2001 in the category "For the best educational and methodological publication'; the winner of the competition "Best Textbook and Textbook" (2006) for the textbook *Managing People in an Organization: Modern Approaches and Technologies*. In 2009, she was awarded a Diploma in the category "Best educational publication in Economic Sciences" of the First Siberian regional competition for the best university book "University Book—2009", in 2011. She was awarded a Diploma in the category "Best Local History Publication" of the Third Far Eastern Regional competition of publications of higher Educational Institutions "University Book—2011". The winner and performer of grants: The Governor of the Tyumen region (2005), Tyumen oblast Duma (2006), RFBR-Ob (2007), KHANTY-MANSI AUTONOMOUS DISTRICT-Yugra (2008), the Committee on Nationalities of the Tyumen Region Administration (2013). Since 2015, according to the Order of the Committee on Nationalities of the Tyumen Region Administration, she has been conducting sociological studies in eight municipalities on the topic: "Studying the situation in the spheres of socio-political, interethnic, and socio-religious relations in the Tyumen region".

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Eugene M. Khartukov Doctor of Economics, Professor at the Department of Management, Marketing, and Foreign Economic Activities named after I. N. Gerchikov. Professor Khartukov is a leading international expert on Russian and ex-Soviet oil and gas issues and oil futures trade. During 1970-82, he has been working in various Research Centers, Departments, and Enterprises of the USSR Ministries of Geology, of oil and gas industry, of foreign trade, and foreign affairs. Since 1980, he teaches World Oil and Energy Markets Research at the Moscow State Institute of International Relations (MGIMO University). Since 1984, he heads the Moscow-based World Energy Analysis and Forecasting Group (GAPMER), advises and consults on oil and gas economics and policies and energy pricing to various Soviet/Russian Ministries, international agencies, foreign governments, private oil and gas companies, consulting firms and financial institutions, as well as to Gorbachev, Yeltsin and Putin Administrations; a Member of the Council of Energy Advisors (USA) and Gerson Lehrman Group (UK) of Energy Consultants.

In 1994–1995—the Head of Russia Energy Project, East-West Center, Hawaii, USA.

Since 1995—the Vice President (for Eurasia) of Petro-Logistics Ltd, Switzerland.

Since 1996—the General Director of (International) Center for Petroleum Business Studies (ICPBS/CPBS), Moscow. Professor of Marketing at MGIMO University.

2003–2012—the Director (for International Affairs) of PetroMarket Research Group, Moscow.

Obtained all his scientific titles (Ph.D., Doctor of Sciences, and Professor) at the MGIMO University, respectively 1980, 1993, and 1994.

Professor Khartukov has authored and co-authored over 360 articles, brochures, and books on petroleum and energy economics, politics, management, and oil and gas in the FSU, Russia's the Far East, the Caspians, Europe, the OPEC, Africa, and ME. Participated as a Speaker and/or a Session Chairman in more than 170 International Energy, Oil and Gas, and Economic Forums. Speaks Russian, English, and Arabic.

Vladislav I. Kiselev Master, Saint-Petersburg Mining University graduated, postgraduate of the Moscow State Institute of International Relationship (MGIMO University), (Moscow, Russia). His scientific interests include sustainable development, decarbonization, hydrogen, oil and gas fields in the arctic zone, and Industry 4.0. Vladislav I. Kiselev actively participates in conferences and works in oil and gas company.

Julia Komagaeva Coordinator of the Central Asia Knowledge Network—The Integrated Knowledge and Capacity Building Program under the Central

Asia Water and Energy Program (CAWEP) at the World Bank. Julia Komagaeva has multifaceted field project management operational experience of more than ten years focused on development, delivery, and monitoring various multi-sectoral WBG operations. Julia Komagaeva has a Master's degree in International Relations. Her current research focuses on innovative approaches to development and knowledge-based solutions to emerging global challenges.

Maria E. Konovalova Doctor of Economics, Professor, Head of the Department of Economic Theory of the Samara State University of Economics, Director of the Institute of National and World Economy.

Nikolay N. Kosarenko, Ph.D. in Law, Associate Professor at the Department of State Legal and Criminal Law Disciplines of the Plekhanov Russian University of Economics. Research interests: financial law, tax law, currency law, insurance law, jurisprudence, and state financial control.

Marina Kovaleva, Ph.D. candidate at the Hamburg University of Applied Sciences, Germany. Her research work focuses on gender issues within the climate change context.

Liliya A. Kripakova, Ph.D. in Engineering, Associate Professor at the Institute of Linguistics and Intercultural Communication of the Sechenov First Moscow State University, (Moscow, Russia). Sphere of scientific interests: digital society and education, and e-learning technologies. She has seven publications in Russian and foreign peer-reviewed journals and books.

Viktoria M. Ksenda, Ph.D. in Economics, Associate Professor at the Volgograd State University. Research interests taxes and taxation, state regulation of taxpayers' work. In Russia, twenty-three scientific papers have been published.

Vladislav V. Kuzmin Master's student, 1st Category Expert in Data Governance Department of Bank of Russia. His scientific interests include sustainable development, digital economy in Industry 4.0, and global hydropower in the world economy. Vladislav V. Kuzmin is a prize-winner of the competition of students' scientific research works at the RUDN University. He regularly publicly presents the results of research work at international scientific conferences.

Elizaveta A. Larkova undergraduate of the department "International Business School and Global Economics" of the Plekhanov Russian University of Economics. Also, she is the economist at the Financial Department of OJSC "Severneftegazprom" (Moscow, Russia), the leading gas producer on the Russian market. Her scientific interests include investment analysis, oil and gas industry and renewable energy sources projects, valuation methods, financial derivatives, project valuation in Industry 4.0, and sustainable development. Being a young scientist, Elizaveta A. Larkova has published several scientific articles devoted to financial analysis and risk management techniques for oil and gas companies in Russia. Now she is actively engaged in the application of the real options for LNG (Liquefied Natural Gas) projects in a highly uncertain post-COVID-19 world together with drastic changes towards "Green economy".

Aleksandra F. Leschinskaya Doctor of Economics, Professor at the Department of Financial Management.

Full Member of the International (European) Association for the Use of Microwave Technologies "AMPERE" (Association for Microwave Power in Europe for Research and Education), The University of Nottingham.

Full Member of the International Academy of Noosphere (Sustainable Development) since June 14, 2012.

Bronze Medal of the VDNKh (The Exhibition of Achievements of National Economy) "For Achievements in the Development of the National Economy of the USSR"—1981.

Jubilee medal of the FNPR (The Federation of Independent Trade Unions of Russia) "100 Years of Trade Unions of Russia"—2004.

Certificate of honor of the Ministry of Education and Science of the Russian Federation—2007.

Yuliya G. Lesnikh Doctor of Economics, Associate Professor.
Education:
Stavropol State University, Accounting, and Audit, 2002
Stavropol State University, Linguistics and Intercultural Communication, 2003
Stavropol State University, 2004 (Postgraduate education)
Autonomous Non-profit Organization of Additional Professional Education "GlavSpets Academy", the program "Using ICT Tools in the Electronic Information and Educational Environment", 2018. Total scientific and teaching experience is 18 years.

Svetlana V. Lobova Doctor of Economics, Professor at the Altai State University (Barnaul, Russia). Her research interests are labor market and employment, entrepreneurship, education economics, digital economy, labor efficiency, integration, and cooperation. Svetlana V. Lobova is the author of more than 300 scientific papers, including those published in highly rated peer-reviewed journals.

Tatiana D. Malyutina, Ph.D. in Economics, Associate Professor at the Department of Economics and Economic Security of the Municipal Budgetary Educational Institution of Higher Education "Volzhsky Institute of Economics, Pedagogy, and Law", the Commercial Director of LLC "TD Seversnab". Scientific interests—Modeling the economic security of business structures.

Irina P. Mamiy, Ph.D. in Economics (1989), Associate Professor.

She has graduated from the Faculty of Economics of the Moscow State University (1981). She was awarded the Badge "In Honor of the 250th Anniversary of Moscow State University", the Medals "In Memory of the 850th Anniversary of Moscow" (1997), and "Veteran of Labor" (2003). Honored Teacher of Moscow State University (2012). She has been working at the Faculty of Economics since 1976. Currently—Associate Professor of the Department (since 1998). Teaching activities include lectures on Statistical Theory, Economic Statistics, International Statistics, and Energy Statistics, and Statistical Methods of Global Research. Irina P. Mamiy's research interests are in the field of hydrocarbon market research. The author of more than 120 scientific papers, including chapters in textbooks "Theory of Statistics" edited by G. L. Gromyko, Moscow: INFRA-M, 2019; "Economic Statistics" edited by Yu. N. Ivanov, Moscow: INFRA-M, 2018; "Fundamentals of International Statistics" edited by Yu. N. Ivanov, Moscow: INFRA-M, 2017; the author of monographs: *Introduction to Energy Statistics*, Moscow: TEIS, 2011; *Statistics of Energy Resources: Theory and Practice*, Moscow: MAKS Press, 2012.

Elena I. Mayorova Doctor of Laws since 1996, Ph.D. in Agriculture since 1978, Professor since 1996, Academician of the Russian Academy of Natural Sciences. The main areas of scientific activity: forensic ecological, forensic biological expertise, forensic science, environmental law. The methodological and theoretical foundations of forensic biological examination have been developed, including the subject of such examinations, the system of concepts that exclude the synonymy of biological and expert terms has been studied, the boundaries of special knowledge of an expert-biologist have been determined, the principles of forensic biological classification, identification and diagnostics have been developed. She has about 140 scientific papers. She has trained four Ph.Ds. in Law.

Olga A. Melitonyan, Ph.D. in Economics, Invited Professor at the Department of Strategic and International Management, Graduate School of Business of the National Research University "Higher School of Economics", Moscow, Russia. Olga A. Melitonyan received her Ph.D. in Economics in 2005 from the State University of Management, Moscow, Russia. For several years Olga A. Melitonyan worked as a Deputy Head of the Corporate Governance Center at the National Research University "Higher School of Economics" which was created in the framework of a joint educational initiative in the field of corporate governance by the Schulich School of Business, York University, Toronto, Canada, and NRU "Higher School of Economics". Currently, Olga A. Melitonyan acts successfully as a lecturer, researcher, and business consultant. Her research interests include corporate governance, corporate strategy, corporate social responsibility, corporations in public policy, and change management.

Alexey V. Mikhailov, Ph.D. student at the MGIMO University. He is a young scientist who already participates in many scientific activities within his university, including internal annual conferences of departments, student conferences, etc. His research interests include the modern world economy, environmental economics, global challenges, and SDG analytics.

Alina G. Mysakova, Ph.D. student in Economics at the Moscow State Institute of International Relations (MGIMO University), Moscow, Russia. Her scientific interests include the concept of sustainable development, green economy, globalization, strategic management and marketing, brand management, branding, rebranding, PR, advertising, and the digital economy. She has published a lot of works in Russian and foreign peer-reviewed scientific journals.

Vitaly Nagornov, Ph.D. in Economics (France), Ph.D. in Sciences (Russia), Leading Researcher at the Center for Applied Research of the Chair "Economic policy and public-private partnership" of Moscow State Institute of International Relations (MGIMO University), Senior Researcher at the National Institute for Accreditation of RusAccreditation, Associate Editor at *Central Asian Journal of Water Research* (CAJWR). Vitaly Nagornov has 18 years of research experience in the field of international relations, economic development, and online ranking. His scientific interests include interactive distance learning, BI, and big data.

Natalia N. Nikolashina Leading Analyst at the National Research University "Higher School of Economics" (Moscow, Russia). Ph.D. student, Junior Researcher of Corporate Finance Problems.

Elena A. Nozdrenko, Ph.D. in Theory and History of Culture, Assistant Professor, the Head of the Department of Advertising and Social and Cultural Activities of the Siberian Federal University. She has 20 years of research and teaching experience in advertising, public relations, imageology, and self-management. She is the author of many publications on communication technologies, marketing, social and cultural management, etc.

Raisa B. Nozdreva Doctor of Economics, Professor, Honored Worker of Science of the Russian Federation. Department of Management, Marketing and Foreign Economic Activities named after I. N. Gerchikova of the MGIMO University.
Academic degrees:
1974—Ph.D. studies in Economics at the Moscow State Institute of International Relations (MGIMO University) with the thesis: "Foreign trade policy in Japan's national programs";
1994—Doctor of Economics with the thesis "Marketing in international management of Japanese companies".
Work experience at the MGIMO University: since 1967.

Professor Nozdreva is one of the Russian international economists who created the basis for the development of such areas in Russian economic

science as marketing, management, and advertising. She is also a famous Russian scientist in the field of Japanese studies.
Subjects taught:
Marketing;
International Marketing;
Crisis Management;
Relevant Issues of International Management;
Management Consulting.
Publications: author of more than 150 scientific papers, monographs, textbooks.
Foreign languages: English, German, and Japanese.
Awards:
The Medal of the Order "For Merit to the Fatherland" (II Class);
The Medal "Veteran of Labor";
The Medal "In Commemoration of the 850th Anniversary of Moscow";
The Medal '200th Anniversary of Ministry of Foreign Affairs of the Russian Federation";
Honored worker of science of the Russian Federation, 2008.

Victor A. Onuchak, Ph.D. in Economics, Associate Professor Academic.
Advanced training:
Professional development program "Information and analytical systems in financial markets (Thomson Reuters Eikon)";
Professional development program "Practical aspects of the development of accounting, statistics, audit, and finance in the digital economy";
Professional development program "Psychological and pedagogical aspects of the work of a university teacher";
Professional development program "Electronic information and educational environment of the university".
Subjects taught:
Statistics;
Business Statistics;
Theory of Statistics;
Economical Statistics;
International and National Rating Agencies and Their Assessments;
International Rating Agencies (On-line course, Stepic).
Work experience: since 2004.
Professional experience: since 2004.
Work experience at the MGIMO: from 2008 to the present.
He has more than 35 scientific and academic publications.

Margarita S. Orekhova, Ph.D. in Economics, Senior lecturer. The total work experience is 11 years. Disciplines taught: Public Relations in Government, Management Theory, Practice for Obtaining Primary Professional Skills and Organizational, and Regulatory Activities.

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Anna V. Ostretsova, Ph.D. in Economics, Associate Professor at the Kuban State Agrarian University named after I. T. Trubilin (Krasnodar, Russia). Research interests: world economy, business safety, and agricultural business. She has over 30 publications in Russian and foreign peer-reviewed journals and books.

Alexander V. Ostroushko, Ph.D. in Law, Associate Professor at the Department of International and Public Law of the Financial University under the Government of Russia. The member of the European Society of Criminology His research interests are legal regulation of information relations, protection of information rights and freedoms of citizens, legal support for information security of minors, and legal regulation of state activities in the information sphere. Repeatedly he was the head and participant of the RFBR grants and grants on the state assignment. The author of over 200 scientific papers in Russian and foreign peer-reviewed scientific journals and monographs.

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(Moscow, Russia). He is the author of many publications in Russian and foreign peer-reviewed scientific journals and monographs in such fields as the economic policy of industrial and post-industrial states, economic security, investment projects in the energy sector, and digital transformation of the world economy. Oleg B. Pichkov is also the head of the digital educational technologies development team at the MGIMO University.

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Svetlana V. Ponomareva Doctor of Economics, Professor at the Department of Control and Audit of St. Petersburg State University of Economics, St. Petersburg, Russia. Her research interests include the theory of value, digital economy, economic growth, sustainable development, globalization, accounting, control, and audit. Svetlana V. Ponomareva is the organizer and participant of All-Russian and International Scientific and Practical Conferences, is the editor and author of collective monographs, and a guest editor of international and domestic scientific journals. She has published over 200 papers in Russian and foreign peer-reviewed scientific journals and books.

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Irina J. Rassolova is a graduate student at the Financial University under the Government of the Russian Federation. She is a young researcher who already participates in many scientific activities within her university, including internal mentoring with undergraduate students, student conferences, etc. Her research interests include digitalization, the modern world economy, green economy and renewable resources, global challenges, and SDG analytics.

Tatiana M. Rogulenko Doctor of Economics, Professor, Professor at the Department of Accounting, Audit, and Taxation of the State University of Management (Moscow, Russia). Her research interests include the theory of digital economy, economic growth, sustainable development, globalization, accounting, control, and audit. Tatiana M. Rogulenko is the organizer of All-Russian and International Scientific and Practical Conferences. She is the editor and author of collective monographs and a guest editor of international and domestic scientific journals. She has published over 200 papers in Russian and foreign peer-reviewed scientific journals and books.

Marina N. Rudenko Doctor of Economics, Professor, the Head of the Department of Entrepreneurship and Economic Security of the Federal State Autonomous Educational Institution of Higher Education “Perm State National Research University”, Perm, Russia. Research interests: development of entrepreneurship in Russia and abroad, sustainable development from the standpoint of the country’s economic security, and digital economy. She has more than 20 monographs and textbooks, more than 220 publications in Russian and foreign peer-reviewed journals.

Alexander I. Samarkin, Ph.D. in Technical Sciences, Associate Professor. His research interests include mathematical, simulation, and semi-natural modeling of technical and biomedical systems, as well as statistics and computer-aided design systems. Alexander I. Samarkin is the author and co-author of four textbooks; one textbook has more than 40 scientific publications in peer-reviewed journals, proceedings of All-Russian and International Scientific and Scientific-Practical Conferences.

Jeff Schubert Professor of International Business, at the new Baikal School of BRICS, Irkutsk National Research Technical University (teaches mainly Chinese students, with a particular emphasis on the high-tech sector).

Previously, Visiting Professor at the School of Asian Studies within the National Research University “Higher School of Economics”, Moscow, where he taught the entire Master’s Degree Module: “Russia’s Asian Foreign Policy” (covering Russian relations with East Asia, South Asia, and Southeast Asia).

Galina N. Semenova, Ph.D. in Economics, Department of Accounting and Taxation, Plekhanov Russian University of Economics and the Department of Economics and Entrepreneurship of the Moscow Regional State University (Moscow, Russia). Her research interests include theory and practice of taxation, audit, accounting, development of small and medium-sized businesses in Russia, digital economy, and Industry 4.0, innovation processes in the economy, and investments. Galina N. Semenova is an Advisor to the State Civil Service of the Russian Federation of the 2nd class, a tax expert of the Federal Civil Service of Russia in Moscow, is the author of collective textbooks and monographs. She has published over 150 papers in Russian and foreign peer-reviewed scientific journals and books.

Larisa A. Sergeeva, Ph.D. in Pedagogy, Associate Professor at the Department of Theory and Methodology of Primary and Preschool Education, Institute of Education and Social Sciences, Pskov State University. Her research interests include theory and methodology for the development of the ecological culture of students, the use of innovative pedagogical technologies in the educational process of schools and universities, digitalization of education. Larisa A. Sergeeva has published more than 120 works in Russian collections of scientific papers and peer-reviewed scientific journals. She is the author of many educational and study guides for students, is a participant in Annual All-Russian, International Scientific and Practical, and Scientific and Methodological Conferences.

Rosalina V. Shagieva Doctor of Law, Professor at the Department of State and Legal Disciplines. Research area: topical problems of law and Theory of State and Law. She is the author of numerous scientific papers. In 2015 she was awarded the Commendation of the Financial University for her active participation in the preparation and hosting of the VI International Scientific Student Congress.

Anastasia V. Sheveleva Doctor of Economics, Professor,

Department of Management, Marketing, and Foreign Economic Activities named after I.N. Gerchikova of the MGIMO University.

Deputy Dean for Academic Programs and Standards School of International Business and Business Administration

Academic degrees:

1994—Bachelor's Degree in Economics (diploma with honors) at the Moscow State Institute of International Relations (MGIMO University);

2003—Ph.D. in Economics at the Moscow State Institute of International Relations (MGIMO University) with the thesis: "International capital flow and foreign investment in Russia at the current stage".

2018—Doctor of Economics with the thesis "Development of institutions and tools for improving the environmental and economic policy of oil and gas enterprises (based on the practice of Russian Southern region)".

Publications: 73 scientific and 33 manuals, seven monographs, 26 articles in scientific journals recommended by the Higher Attestation Commission, 40 articles in other journals and conference abstracts, 33 textbooks, study guides, methodological recommendations. Hirsch index (RSCI): 12.

In recent years Professor Sheveleva has been developing the theory of environmental economics and the concept of environmental and economic policy of oil and gas enterprises.

Ekaterina I. Shumskaia, Ph.D. in Economics, Senior Lecturer at the Moscow State Institute of International Relations (MGIMO University). The author has one monograph and more than 20 publications in journals recommended by the Higher Attestation Commission and in journals indexed in Scopus in areas, such as economic growth, labor productivity, the Fourth Industrial RevolDamiution, the Digital economy, etc. She conducts lectures on Economic Political Science and Government Regulation. The author's course "Economic potential of modern technologies" was independently developed and introduced into the studying program at the MGIMO University.

Yuriy I. Sigidov Doctor of Economics, Professor. He is the Head of the Department of Accounting Theory of the Kuban State Agrarian University named after I.T. Trubilin. Research interests: theory of accounting, management studies, and legal regulation of the work of an accountant. More than 300 scientific papers have been published in Russia.

Marina D. Simonova Doctor of Economics, Professor of Statistics at the MGIMO University, Department of Accounting, Statistics, and Auditing. Doctor in Accounting and Statistics of the Higher Attestation Commission of the Ministry of Education and Science of Russia in 2011. Spheres of scientific research: methods of SNA, Structural Business statistics in the analysis of Globalization, Digitalization, energy industry, renewable energy sources, online aggregators. Publications: more than 115 scientific and academic publications. Four papers in Scopus and WoS bases. Elected Member of the International Statistical Institute. Member of IARIW etc.

Subjects taught: "Economic statistics", "System of National Accounts", "Statistics" (in English)—Bachelor Double Diploma Program in Politics and International Relations, University of Reading (UK). International Standards for Economic Statistics (in English)—Master Double Diploma Program in International Management, ICN Business School (France). Statistics for Social Science—Bachelor Double Diploma Program of HSE and Kyung Hee University (Korea).

Anna A. Skomoroshchenko, Ph.D. in Economics, Associate Professor at the Federal State Budgetary Educational Institution of Higher Education "Kuban State Agrarian University named after I.T. Trubilin" (Krasnodar, Russia). Research interests: food security, investment policy, entrepreneurship, and digital economy. She has 96 publications in Russian and foreign peer-reviewed journals and books.

Tatiana V. Skryl, Ph.D. in Economics, Associate Professor at the Department of Economic Theory. During 2015–2020 she has published articles in journals: indexed in the Scopus database—16 articles; included in the list of scientific journals recommended by the Higher Attestation Commission—8 articles; accounted for by the RSCI—more than 40 articles.

Irina V. Sokolnikova, Ph.D. in Economics, Associate Professor of Financial Management Chair. M.B.A. Programmes Academic Supervisor: Corporate Finance and Finance. She has over 25 years of experience at the leading Russian universities (Plekhanov Russian University of Economics, Higher School of Economics, Lomonosov Moscow State University, and Russian Presidential Academy of National Economy and Public Administration). Twenty years of teaching in Double Degree Programs at Bachelor's and Master's levels; consulting and training project for the largest Russian companies.

Her scientific interests include investment project evaluation, financial management, and the digital economy, and Industry 4.0. She has published more than 45 works in Russian and foreign peer-reviewed scientific journals and books.

Maria I. Sokolova, Ph.D. in Economics, Professor at the Department of Management, Marketing, and Foreign Economic Activities named after I. N. Gerchikov of the MGIMO University.
Academic degree
1973—Degree in Economics (with honors) at the Moscow State Institute of International Relations (MGIMO University).
Work experience: since 1972.
Professional experience: since 1973.
Professor Sokolova has more than 40 years of experience in teaching and over 35 years in marketing research.
Subjects taught:

- Marketing;
- Strategic Management;
- Marketing Research;
- Organizational Behaviour.

Publications: the author and scientific editor of 15 books and five textbooks.
Professor Sokolova has more than 7,500 pages of scientific publications, in the preparation of which she used the materials and experience obtained in the process of working in Russia and abroad. Also, she creates case studies and business games, which she uses in the framework of her courses. She is a consultant to the business incubator MGIMO University.
Awards:
The Jubilee Medal "In Commemoration of the 100th Anniversary of the Birth of Vladimir Ilyich Lenin";
The Medal "In Commemoration of the 850th Anniversary of Moscow";
The Medal "200th Anniversary of Ministry of Foreign Affairs of the Russian Federation";

MGIMO University's Medal "For Merit".
Professor Sokolova actively collaborates with leading domestic and foreign educational, research, and advisory centers as well as with the enterprises, which allows moving the learning process closer to the practical requirements.

Victor V. Sorokin, Ph.D. student at the Department of Foreign Economic Activity in the Field of Energy Transportation at the MGIMO University and an employee of Gazprom Neft. His research interests include sustainable development, decarbonization of the oil and gas industry, digital technologies, theory of international economic relations, and relations within OPEC+. Victor V. Sorokin is a participant in Russian and International Scientific and Practical Conferences, the author of various articles on the oil and gas business, and an active employee of Gazprom Neft Khantos.

Ellen E. Starostina Senior Lecturer at English Language Department No. 6 at the MGIMO University. She has been working at the MGIMO University since 2010. She teaches courses in English for Specific Purposes as well as courses in General English, English Grammar and Speaking, Reading to second, third, and fourth-year students. She has authored and co-authored books on home reading and ESP.

Nikolay V. Studenikin, Ph.D. in Political Science, Director of the "New Quality of Life" Foundation, Associate Professor of the Department of Economic Policy and PPP of the Moscow State Institute of International Relations (MGIMO University), Moscow, Russia. His scientific interests include the theory of political and economic growth, sustainable development, and green economy, Corporate Social Responsibility (CSR), and Public-Private Partnership (PPP). He has published more than 50 articles on public-private partnerships, the green economy, and sustainable development. He participated in preparing and hosting many federal events, conferences, and forums (Russian Environmental Week, IV All-Russian Congress of Ecologists, etc.). He holds a Commendation from the Vice-Speaker of the Federation Council of the Russian Federation and a Commendation from the President of the Russian Federation for Socio-Political Projects.

Arina A. Tinkova the 2nd year Master's student at the International Economic Relations Department of the People's Friendship University of Russia (RUDN University). Scientific interests: global markets and trade policy.

Alexey K. Titov, Ph.D. in Economics, Associate Professor at the Samara State Technical University, Samara, Russia. He has ten publications in Russian and foreign peer-reviewed journals and books. Junior Researcher.

Lyudmila V. Tokoun, Ph.D. in Economics, Professor, Associate Professor. From 1996 to the present time, Associate Professor, Professor at the Department of Finance and Credit of the State University of Management; 2007–2014—Director of the Center for Additional Educational Services of the

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Climate Change Combating Regulatory Framework in the Future Economy in Industry 4.0

Environmental Legislation of the Russian Federation from Consumers' Ideology to Value-Conscious Approach to Natural Resources

Elena I. Mayorova, Rosalina V. Shagieva, Nikolay N. Kosarenko, and Alexander V. Ostroushko

1 Introduction

The Russian Federation, thanks to its vast territory and the variety of natural and climatic zones, is an essential factor in the preservation of planetary ecological well-being. Environmental function, environmental protection is one of the most important directions of state policy of Russia). "In the broad sense of the word, the field of environment protection is an environment-oriented field and a field of natural resources, which become very essential for understanding, studying, and regulating social being" (Tikhomirov, 2012). In a climate of the deteriorated natural biological component of the land, the importance of the legislative regulation of prevention and limitation of negative environmental impacts as well as sustainable use of natural resources increases. In this regard, legal regulation of environmental relations is achieved

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due to a vast number of regulatory legal acts of integrated nature. Environmental and natural resources relations, being environmental in matter, can be relegated to other legal branches according to their form. For example, the rights and obligations of citizens in the field of environmental protection can be considered as the issues of constitutional right; the right of ownership of natural resources can be considered as civil law; responsibility for environmental crimes and law violations can be considered as criminal and administrative law.

Despite the fact that environmental legislation includes over a thousand of regulatory legal acts and about 4 thousand standards, we cannot say that environmental relations are adequately regulated. Current legislation fails to answer the question of how to secure the constitutional right of citizens to favorable environmentit is increasingly degrading. This is due to the existing perception of natural wealth as something that mankind has received, once and for all, for free, and therefore has no special value. A human is primarily characterized by consumption rather than protection. Within this ideology, an economic cycle has developed—models of production and consumption, trade, production sector, land use and urbanization. The radical reconsideration in the field of setting allowable limits of human impact on nature is only possible when the attitude to nature conservation as an inexhaustible source of free goods changes. Unfortunately, people who are aware of significance of nature, are not engaged in lawmaking.

According to many scientists (Bogoliubov 2015; Brinchuk 2011; Veber 2016; Golichenkov 2016, pp. 3–4), if the dominant ideology of the attitude toward nature conservation is not changed, the death of mankind in the immediate future is unavoidable. Only a revulsion in the worldview of people and their awareness of their unity with nature can contribute to slowing down and reversing this process. This requires concerted efforts by the State in environmental education of citizens, formation of environmental culture at all levels of education, and eventually—creation of a new worldview.

2 Methodology

The legal analysis of Russian environmental legislation from the perspective of the concept of sustainable development, as well as the results of fundamental and applied research of domestic scientists in the field of environmental protection and economics of natural management, proceedings of scientific and research-to-practice conferences served as a theoretic and methodological framework for this research. The implementation of this concept is necessarily associated with the preservation of the biosphere and natural capital (Glazyrina 2001). The model of sustainable development of resource utilization has been developed to enable a human fill his/her needs while conserving environment in order to preserve the possibility to meet the needs of future generations (Reimers 1992, p. 367).

The dialectical method, analysis and synthesis methods, the method of the unity of historical and logical, scientific abstraction method, systemic approach method and other methods were widely used in the course of the research, since they repeatedly proved their effectiveness to authors in understanding environmental problems (Khvatova et al. 2019, pp. 4949–4954; Zaripova et al. 2019, pp. 5027–5031).

3 Results and Discussion

As follows from the analysis of the state of environmental legislation in Russia, the authors have found the mitigation of its environmental aspect, a tendency of transition of environmental-economic relations into purely economic relations, civil relations; consideration of natural objects solely as natural resources. Mandatory use of emergency declarations on every possible protection and conservation of natural objects in all natural resources codes and laws, their sustainable use to meet the spiritual and material needs of Russian citizens cannot hide the desire to include even the most vulnerable and specially protected objects in economic activity.

The resource-based economy of Russia requires the introduction of an increasing number of natural objects. This includes mining operations, laying of pipelines, clearance of solid ranges of valuable forests, and topsoil devastation. The President of the Russian Federation at a large press conference on December that was held on 14.12.17 in Moscow, called for searching for a middle ground “between economic development and environmental protection”. Before that time, however, he had spoken more aphoristically and strongly: “the environment should not interfere with the economy”. In pursuance of this slogan, the legislator virtually stopped taking public interests in the field of environmental conservation and sustainable natural management into account. Therefore, there is no point in being surprised about the fact that the environmental laws are characterized by declarativity, as if the preamble to which states that the document is adopted for the benefit of the Russians; there is no point in putting ourselves to some bother related to the development of regulations for different procedures and effective mechanisms for implementing legislative requirements. Amendments and changes are introduced to environmental laws almost as early as the next day after their adoption; new articles and requirements appear, etc.

The “garbage law” may serve as an example, since it has begun to develop since the adoption of fundamental law No. 89-FZ “On production and waste consumption” of 24.06.1998. The law has been amended 39 times since that time. In recent revisions, the incineration of municipal solid waste, which is protested against by ecologically-minded society, has been made equivalent to its recycling.

At the same time, the vision of subsidiarity of natural wealth compared to the benefits of civilization implanted by the government institutions, has been widely understood in society. The consumer attitude to nature conservation leads to the formation of a relevant ideology, when acts unlawful associated with natural objects, are not considered to be unlawful in actual fact. Despite the existence of Chapter 26 “environmental crimes” in the Criminal Code of the Russian Federation, the proportion of criminal cases initiated over 16 elements (Articles 246–262) does not exceed a hundredth of a percent of the total number of cases. Impunity, in turn, entails an increase in the number of environmental offences—a kind of vicious circle is formed.

Many environmental laws create the impression of the state’s weariless concern about the conservation of nature of the country. The legislative regulation of all relations, which are one way or another associated with land, begins with the provisions of the fundamental law of the State. Pursuant to Article 72 of the Constitution of the Russian Federation, the issues of ownership, use and management of land, as well as subsurface resources, forest and other natural resources; natural management; environmental protection and environmental security, as well as specially protected natural areas are jointly managed by the Russian Federation and constituent entities of the Russian Federation. The Federal Laws are issued according to the joint authority matters, and laws and other regulatory acts of constituent entities of the Russian Federation (Article 76 of the Constitution of the Russian Federation) are adopted pursuant to them.

Legal acts of constituent entities of the Russian Federation are of paramount importance within the framework of environmental legislation. The total number of legislative acts in constituent entities of the Russian Federation is increasing and totals several hundred. Their publication is aimed at taking into account the natural, geographical and climatic features of a particular region. Acts have appeared that have no comparable counterparts at the federal level—for example, Law of the Voronezh region No. 94-OZ “On drinking water” of 09.10.2007, Law of the Kaliningrad region “On environmental policy” of 21.06.1999, the Environmental Code of the Republic of Korbashtostan of 28.10.1992 (as amended on March 4, 2014) et al.

Environmental legislation, due to the complex character of natural management, is a complex system of regulatory acts which includes two main groups: natural resources group and environmental group. The first group includes regulatory legal acts that were adopted to regulate relations of the sustainable use of certain components of the natural habitat. The second group includes legislative acts on environmental protection and ensuring environmental security.

The use and protection of nature is implemented through the application of provisions of the fundamental law of environmental legislation—Federal Law No. 7-FZ of 10.01.02 “On Environmental Protection”, determining the legal framework of state policy in this field. The Law “regulates relations in the field of interaction of society and nature that arise during economic and other activities related to environmental impact”. In the quote from the enacting clause, nature is considered as the subject of law, which, in our opinion, is not quite correct. However, some authors (Yugov 2017) recognize the legal capacity of nature; yet, in our opinion, the legal concept of legal capacity is not applicable to it, since the presence of nature of rights as well as the human-nature partnership relations can only be claimed in a figurative sense (Falko and Lukmanov 2015). It seems more correct to use another expression, which is less flashy yet more reflective of the existing state of affairs: “relations in the field of nature conservation and sustainable use of natural resources”.

This Law has suffered numerous changes over the period of its operation. It is characteristic that it replaced the Law on protection of the natural habitat. This lexical change is very reasonable. Without going into scientific details, it should be stated that natural habitat and environment are absolutely different concepts. Natural habitat is an area that is not inhabited (by a man), its space is not managed, but is only limited by those natural processes which are significant to a human. The concept of environment implies a dominant subject, located in a certain environment that has a particular impact on it. With the anthropocentric paradigm, a man is considered to be such a subject, while nature exists to meet his diverse needs. “The natural habitat”, according to the interpretation by N. Reimers, is “a set of abiotic and biotic environments which impacts a human being and his/her economy, i.e. a combination of purely natural and natural-anthropogenic bodies and phenomena, directly and indirectly affecting a human and natural-resource economic indicators of the economy” (Reimers 1992).

It is common practice to understand to treat both natural and artificial (man-made) environments as (human) environment. This is also reflected in Federal Law No. 7-FZ—positive law is able to take into account natural law and can meet the social and economic needs of society in the best possible way (Bogoliubov et al., 2010).

The specific character of law-making of a particular branch cannot but affects the stability of the legislative regulation. The reform in the field of environment protection has started as long ago as in 2014, when Federal Law No. 219-FZ “On Introducing Amendments to Federal Law “On Environmental Protection” and certain legislative acts of the Russian Federation” of 21.07.2014 was adopted. In July 2016, its revised version was adopted again, and amendments were subsequently introduced to it every year. Thanks to 48 changes, the law that was intended to protect the environment has been enriched with articles on organizational and monitoring activities. As a result, it introduced numerous requirements for economic and other activities and became a kind of administrative regulation whose purpose was not so much to preserve the environment as to bring economic activity, associated with natural objects, in line with specific rules. We should note that any activity involves the natural component anyway: location on a land plot, discharges and emissions, etc. The updated law prescribes availability of natural management at a fee, as well as the procedure for the calculation of a fee for the negative impact on the environment (NIE), and correction factors to these payments were introduced at the disposal of waste; a new system for the rationing of economic entities according to NIE items have been introduced, demanding obtaining an integrated permit (IP) by legal entities and individual entrepreneurs carrying out economic and (or) other activities on objects of categories 1–3; the need has been established to obtain a permit for emission of polluting substances in the atmosphere and their limits for the emission of polluting substances into environment, to discharges and disposal of polluting substances; waste generation norms, requirements to small and medium-sized business entities operating the NIE items assigned to Category I subject to federal state environmental supervision, etc.

Notwithstanding the fact that this Law is intended to replenish the state budget rather than to protect nature, it introduced numerous requirements for economic and other activities into the legislative framework which has negative environmental impact.

The legal institution of State ecological appraisal which has existed since 1995 was established with a view to preventing ecological murder through proactive identification of hazard of any economic activity. Ecological appraisal was a critical deterrent to irresponsible management of nature. However, this legal institution has been heavily destroyed due to reforms in the last few years, and after the introduction of numerous amendments, the procedure of ecological appraisal has almost transformed into a slogan. In addition, the Federal Appraisal is managed by the Federal Service for Supervision of Natural Resource Usage which is subordinate to the Ministry for the Protection of the Environment and Natural Resources of the Russian Federation, so it saves us effort of suggesting its impartiality. Instead of a scientific justification for the safety of a planned activity, only the properly compiled documentation is now required for its implementation. This is another manifestation of the stance of mitigation of environmental legislation that has emerged a decade and a half ago. The State ecological appraisal is aimed at "…establishing the compliance of documents and (or) papers substantiating economic and other activities planned in connection with the implementation of ecological appraisal, with environmental requirements specified in technical regulations and environmental legislation, with a view to preventing adverse impact of such activities on the environment" (Article 1 of Federal Law No. 174-FZ "Concerning Ecological Appraisal" of 23.11.1995). However, there are some positive shifts: since 2014, this Law has become harmonized with Federal Law No. 7, while the list of objects of State ecological appraisal as well as documents necessary for carrying out of hazardous activities, has been expanded. It is now necessary to present the design documentation for the capital construction objects falling within Category I, as well as the materials substantiating a new type of environmental regulatory documentation—integrated permit (IP).

Nevertheless, the real consideration of risks to prevent threats to environment occurring during the natural management, has been converted not to actual actions, but to declared intents. In a point of fact, in order to simplify the production process, save time and money, intents stated in the declaration are hardly ever respected. Low susceptibility of Russian business to the introduction of best available technologies impedes sustainable natural management as well.

The dynamism of legislation on environmental protection in general and on the State ecological appraisal in particular encourages cautious optimism—one may hope to further control of the irresponsible management of nature.

Despite the fact that the implications of negative man-caused environmental impact are most often manifested in a complex way, affecting the entire eco-system, special aspects of natural objects require special approaches to a particular type of natural management.

The largest number of codified legislative acts compared to other branches introduce their specifics to the system of Russian environmental legislation. Federal Law No. 7 has less legal force relative to them. However, its ideological significance is that all natural resources codes contain references to the provisions of the Law.

Natural Resources Law consists of self-sufficient subbranches, and each of them is headed by a systemically important regulatory legal codified act.

The Land Code of the Russian Federation is a document which regulates land relations. It, just like other natural resources codes, outlines the principles of the industry, which should be guiding in the course of business decision-making, and in case of conflict situations they should guide the disputing parties, judicial and administrative bodies.

Pursuant to the Land Code of the Russian Federation, land is deemed to be "a natural object that is protected as the most essential component of nature, a natural resource that is used as a means of production in agriculture and forestry and the basis for carrying out of economic and other activities within the Russian Federation, and at the same time as a real estate, as an item of property, and other land titles" (Article 1 of the Land Code of the Russian Federation). The transition of the State to the market-oriented model of development has marked a kind of new, but actually not well-forgotten old attitude towards land—it has been recognized as a real estate and has acquired an owner. There was a process of differentiation of forms of ownership of land: the lands that belonged to the Russian Federation, constituent entities of the Russian Federation and municipal entities, were allocated; the property to land plots of individuals and legal entities is guaranteed as well.

These innovations resulted in oppositely directed and contradictory trends in development of land legislation and law. The extraordinary complexity of this section is determined by the genetically determined interdependence between land relations and relations of subsurface resources, waters, forests, and other natural objects, as well as systemic connection to such branches of legislation as civil legislation, town-planning legislation, administrative legislation, etc. Several Federal Laws were adopted as long ago as early in the third millennium to take into account land resources: "On State Land Cadastre", "On Land Utilization", "Concerning the state provision of fertility of agricultural lands", "On Land Reclamation" et al. However, land relations were gradually transformed into land and legal relations, which largely "washed out" the environmental component of them. The two last-mentioned laws have not been repealed, but have been subject to major changes; many statutory provisions thereof have become null and void.

At present, land legislation has been almost completely redesigned compared to that of the first decade of the twenty-first century. Federal Law No. 171-FZ "Concerning the introduction of amendments to the Land Code of the Russian Federation and certain legislative acts of the Russian Federation" of June 23, 2014 (hereinafter referred to as Federal Law No. 171), Federal Law No. 452-FZ of 30.12.2016 "On Introducing Amendments to Federal Law "On the State Real Estate Cadastre" and Article 76 of Federal Law "Concerning Education in the Russian Federation" with regard to the improvement of the activity of cadastral engineers", Federal Law No. 218-FZ of 13.07.2015 "On state registration of real estate" (effective since 2017), Federal Law No. 237-FZ of 03.07.2016 "On state cadastral valuation" (effective since 2017) changed the principled approach to regulation of land relations. These acts served to introduce new rules for the provision of land plots, land supervision and monitoring, the rules of withdrawal of land for public and municipal needs, enabled comprehensive cadastral activities, the terms of cadastral activities have been changed, cadastral integration and registration of real estate rights have been performed, the terms of cadastral valuation have been changed, etc. According to scientists, all abovementioned innovations "were aimed at completing the institutional transition from the planned economy and the monopoly of public property in land to market land relations both in the Arbitration Procedure Code of the Russian Federation and in other fields" (Lipski 2015, p. 18). However, the analysis of agricultural practices shows that in 2016, 24.3 million hectares of arable land were not used in the country (Khlystun 2015).

In the Russian Federation, all lands are divided into 7 categories in accordance with their designated use (Paragraph 2 of Article 7 of the Land Code of the Russian Federation)—agricultural lands, lands of inhabited localities, water reserve land, forest land etc. for permitted carrying out of a particular activity within them. There were law-enforcement problems in this field, particularly regarding the establishment and amendment of the legal regime of land plots. However, Federal Law No. 171 was revolutionary, particularly in the context of the use of land of inhabited areas. To enable the unimpeded site development of land of municipal entities, the Law provides for the zoning of territories, the procedure for which is prescribed in the Urban Development Code of the Russian Federation (hereinafter referred to as the Urban Development Code). Permitted use of the land plot as part of land by the Urban Development regulations, forming part of the land-use and site development recommendations (Paragraph 1 of Part 6 of Article 30 of the Urban Development Code). Pursuant to them, any type of permitted use of species provided for by zoning of territories, is selected by the investor independently, without additional permits and reconciliation procedures. This innovation was introduced under a pressure from the construction lobby to prevent city people from speaking against site development of landscaped urban areas. As O. Romanova points out, “the zoning institute could be much more efficiently used within the land category system by means of modernization of the traditional institute of land law” (Romanova 2016).

Despite the fact that amendments are constantly introduced to the Land Code of the Russian Federation, many of them being meaningful,—this regulatory act preserves “basic institutional provisions and a principled approach to the use of land as natural object, natural resource and real estate item at the same time” (Galinovskaya 2012, p. 8). The land conservation requirements which have been almost superseded by civil law issues, are not cancelled and include activities prescribed in Paragraphs 1–3 of Article 13 of the Land Code of the Russian Federation and intended for land users, landowners and lessees of land plots: this is “restoration of fertility of agricultural lands; protection of lands from water and wind erosion, mudslides, flooding, waterlogging, resalinization, aridization, consolidation, pollution with chemicals, including radioactive substances, other substances and microorganism, pollution with production and consumption waste, as well as other adverse impact; protection of agriculturally used areas from the occlusion by trees and shrubs, weeds, maintenance of the achieved level of land reclamation”.

In order to ensure security and sustainable use of land, restrictions and additional duties may be imposed on the use of land plots. In general, however, one should acknowledge that there is a mitigation of environmental aspect in the field of land use and highlighting the issues of ownership and civil land turnover.

The legal regime of subsurface resources which are inextricably connected to land is established by mining legislation, the fundamental act of which is Federal Law No. 27-FZ “Concerning the introduction of amendments and additions to Law of the Russian Federation “On subsurface resources” of February 8, 1995 (as subsequently amended and supplemented). The law obliges the users of subsurface resources to thoroughly study and sustainably use the deposits of natural resources ashore and on the continental shelf.

The legal notion “subsurface resources” is not identical to the notion “natural resources”. Moreover, if subsurface resources are exclusively owned by the state and its constituent entities, some useful (publicly available) resources can be privately owned.

Sites of subsurface resources are provided for use under a license for a certain period or for an unlimited term. Legal literature points out that “Conclusion of licensing agreements during the provision of subsurface resources for use is a form of the use of provisions of public law, but implies a staged implementation of a certain number of civil law contracts under the terms of individual types of use of subsurface resources” (Dudikov 2017, p. 45).

The use of subsurface resources falls within jurisdiction of the Ministry for the Protection of the Environment and Natural Resources of the Russian

Federation and its subordinate agencies. The Ministry always tends to use natural resource development rather than nature conservation. This, in particular, threatens the existence of regional specially protected natural areas (SPNA). A typical example is withdrawal of land in the national park "Yugyd Va" within the boundaries of the World Heritage Site "The Virgin Forests of Komi" for the management of gold mining by CJSC "Goldminerals". The interests of CJSC owned by four Cypriot companies, were lobbied by the Head of the Komi Republic. Notwithstanding the fact that withdrawal of land in the national park for gold mining was recognized illegal twice by the Supreme Court of the Russian Federation, the Head of this region placed the representatives of the Ministry for the Protection of the Environment and Natural Resources of the Russian Federation and its subordinate authorities under the obligation to survey the territories of national park for the identification of land plots "which lost their environmental significance" and their subsequent expulsion from SPNA. It should be noted that the vague wording of the loss of "environmental significance" is very often used in practice: it is generally used to transfer the land plots to another category after illegal logging or burning-out of trees; after illegal site development of the territory, etc.

Product sharing agreement which is an agreement concluded between the Russian Federation and the business entity, pursuant to which the investor "is granted exclusive rights to search for, explore, and mine mineral raw materials at a site of subsurface resources specified in the agreement, and to carry out related on a remuneration basis and for a specified period, while the investor is obliged to carry out abovementioned works at his own expense and at risk". The agreement defines all necessary conditions related to the use of subsurface resources, including the terms and procedure for sharing the goods manufactured between the Parties to the agreement pursuant to the provisions of the "Law" (Article 2 of Federal Law "On subsurface resources"). That said, Article 23 makes a number of requirements to the sustainable use and protection of subsurface resources. Alongside with requirements for the protection from pollution "especially in case of underground storage of oil, gas or other substances and materials, dumping of wastes" which are common for all natural resources, the paper gives consideration to the impact of specific "factors that reduce the quality of natural resources and the economic value of deposits or complicate their development". As is known, the pollution of aquatic areas during crude-oil production from the sea and ocean beds is particularly dangerous, but the oil production with the concurrent pollution of the land is equally detrimental to fauna and flora. A typical example is a federal-scale emergency, which occurred on May 29, 2020, when a tank of diesel fuel was depressurized at CHP-3 in Kayerkan, a district in Norilsk. It is one of the largest oil spills in the arctic zone in history, posing a threat to the ecosystem of the Arctic Ocean.

The combination of environmental, economic and social interests during the use of subsurface resources is a basic but not always maintained principle of modern mining law—in the context of the resource-based economy, interests which have nothing in common with nature conservation rise to the fore.

Scientists and politicians argue that the wars of a new age will not be for oil and other power resources, but for water. Water is an essential “natural component of the natural habitat, huge drinking, industrial production, fish, recreation, marsh, etc. resource. Various intended use of water resources requires diverse legal regimes of their conservation and use” (Tikhomirov 2012). Water relations are regulated by the Water Code of the Russian Federation and several regulations. Water legislation is characterized by the establishment of mainly federal ownership of water bodies—this is what differs it from land legislation. However, since there are water reserve lands and protected shoreline belts, water legislation is inextricably connected to land legislation.

The Water Code of the Russian Federation regulates the issues of ownership of water bodies, water use, and protection of water bodies. Most Russian water reservoirs are assessed as “bad”. The quality of water impedes the restoration of reserves valuable aquatic bioresources. Permanent pollution of water bodies prevents people from using drinking water that is safe in terms of hygienic requirements. The problem of provision of drinking and process waters is largely resolved through water conservation and wastewater treatment, which gives rise to many complaints.

The Water Code of the Russian Federation places special emphasis on the issues of management using mechanisms such as “planning of the sustainable use of water bodies (Article 79); control of admissible impact on waters (Article 35); State monitoring of water bodies (Article 30); State Register of Aquatic Resources (Article 31); State monitoring and supervision in the field of the use and protection of water bodies” (Article 36).

The adoption of the Water Code of the Russian Federation was accompanied by violent controversy. The abolition of the licensing form of water use and its replacement with a contractual form, “tacit” abolition of water servitudes, the transfer of powers to prevent the adverse impact and eliminate its consequences, underground water abstraction not limited to specific provisions, to the executive authorities of constituent entities of the Russian Federation, as well as other disputable points have not yet been fully resolved to date.

Water conservation zones—“territories that border upon the shoreline (boundaries of the water body) of seas, rivers, streams, canals, lakes, reservoirs, and on which a special regime is established for carrying out economic and other activities with a view to preventing pollution, littering, as well as mud accumulation in abovementioned water and depletion of their waters, as well as conservation of living environment of aquatic biological resources and other items of fauna and flora”—were historically allocated to prevent adverse impacts on waters (Paragraph 1 of Article 65). However, compared to the prior Water Code of the Russian Federation of 1995, dimensions of water conservation zones were significantly reduced; however, they are completely absent in cities and towns. This complicates the task of protection and sustainable use of water bodies: "As a result, heavy development of the banks of lakes, reservoirs, rivers and streams was started, destroying ecosystems, forests and vegetation which exercised water regulation and water conservation functions" (Veselov 2008).

The UNESCO World Heritage Site (WHS), "Lake Baikal", plays an exclusive part in the regulatory system of aquatic biological resources. Its value and uniqueness required the adoption of Federal Law No. 94-FZ "Concerning the Conservation of Lake Baikal" of May 01, 1999. Nevertheless, the mode of operation of Baikal PPM "since May 2010 till September 2013 involved waste water discharge directly into the lake in violation of the current legislation. Moreover, these violations were systemic: the production technology and the equipment used precluded compliance with these norms" (Maksimova 2014). In order to protect the unique ecosystem of Lake Baikal, special regime of economic and other activities was established within Baikal natural area. However, Decree of the Government of the Russian Federation No. 603-R of April 27, 2012 granted permission to the placement of guest houses, utility and transport infrastructure facilities within the biosphere proving ground of Barguzin wildlife reserve (world heritage plot "Lake Baikal").

The shortcomings of VK-2006 necessitated introducing nearly 40 changes to the adopted document.

Federal Law No. 96-FZ "Concerning ambient air protection" of 04.05.1999 (as amended) defines this natural object as an "essential component of natural environment, which is a natural mixture of atmospheric gases outside of residential, industrial and other premises" (Article 1 of the Water Code of the Russian Federation). Due to the constant movement and continuous mixing which cannot be controlled by a human, the atmosphere cannot be individualized, hence, it cannot be an item of property. However, the State has sovereign rights to its airspace.

Today, the atmosphere, its ozone layer, and the near-Earth environment are increasingly seen as a whole, forming an ecological but not a legal unity: only the atmosphere is generally subject to legal protection.

The industry-specific Federal Law does not provide for the regulation of the use of ambient air, yet it provides a definition and sets the goals for its monitoring. Requirements for economic and other activities, which have adverse physical impact on the atmosphere, have been formalized in legislation. In addition, the norms of ambient air protection are prescribed in Federal Law "On Environmental Protection" and Federal Law "Concerning Ecological Appraisal". This includes control of the adverse physical impact on the atmosphere; setting emission quotas and impacts; state registration of harmful and hazardous substances; issue of permits to the emission of harmful (polluting) substances and to the adverse physical impact on the atmosphere, setting the maximum allowable emissions; setting requirements for economic and other activities which have adverse impact on the atmosphere. Ambient air protection is one of directions of the implementation of state policy in the field of environmental protection—is based on the principle of obligatory nature of state regulation of emission of harmful substances in the atmosphere.

Despite the measures taken, more than two thirds of the Russian population live in a climate of persistent pollution of atmosphere. According to the research of the FinExpertiza auditing and consulting company based on the data from the Russian Federal Service for Hydrometeorology and Environmental Monitoring (RosGidroMet), 44 cases of high air pollution were registered for the first quarter of 2020 in Russia, which exceeds the total amount of substantial emissions for the same period in 2019 by 57%—28 cases (according to the research of the FinExpertiza auditing and consulting company based on the data from the Russian Federal Service for Hydrometeorology and Environmental Monitoring (RosGidroMet) (https://www.rbc.ru/business/25/05/2020/5ec6a0b39a7947d276ceca8f).

Various indicators of ambient air condition are regulated by Decrees of the Government of the Russian Federation—for example, Decree of the Government of the Russian Federation No. 182 "On the procedure for establishing and revising environmental and hygienic norms of the quality of ambient air, maximum permissible levels of physical impacts on the atmosphere, and state registration of harmful (polluting) substances and hazardous substances" of March 2, 2000.

Applicable legal requirements are adapted to current realities in practice. For example, if it is impossible to reduce the amount of emission of harmful substances by an enterprise, executive authorities in this field can set temporarily approved emission limits, although this permitted knowing violation can significantly exceed allowable concentrations of atmospheric pollution.

Perhaps no natural resource has suffered as much as the forest as a result of continuous reforming of environmental legislation. Russian Federation owns 20.1% of world's woodlands. However, the volume of wood production accounts for 2% of the world's volume and 1.1% of the country's GDP. The Ministry for Economic Development developed 36 draft versions of the new Forestry Code of the Russian Federation, reflecting the opinion of economists according to which too much land is excluded from commercial sales due to the presence of unwanted fir trees within it. The adoption of the Forestry Code of the Russian Federation was preceded by disturbances among environmentalists, dissenting opinions of authoritative scientists in the field of forest management, remonstrative appeals to the Government, open letters to the President of the Russian Federation, one of which was signed by the former Patriarch Alexius II.

The ban on free stay in forests and the right of lessees to enclose forest plots excited particular indignation among citizens. Nonetheless, the Forestry Code of the Russian Federation and Federal Law No. 201-FZ "Concerning the enforcement of the Forestry Code of the Russian Federation" of 04.12.2006 were adopted—like all unpopular laws, before the New Year. There was no definition of the notion "forest" in the Forestry Code 2006; hence, the term "forestry" was abrogated. Experts in the field of forest management were indignant about the incorrect expression "forest use" instead of the generally accepted expression "utilization". When the lawmaker introduced a contradictory and obscure definitions to the Forestry Code of the Russian Federation, he showed no respect for the traditions and fundamentals of domestic forestry and forest management (Brinchuk 2012).

New Code voided such "superfluities" as fire protection service, abolished the established division of forests into groups, and introduced a new classification of forests depending on their use; however, there was no norm that would directly make provision for countering illegal logging and violations of the prescribed forest use procedure. There emerged a revolutionary possibility of existence of various forms of ownership of forest plots as part of lands of other categories, except the forest fund, along with the public form of ownership. The forms of ownership were determined in accordance with land legislation.

In 2008, the forestry farms were transformed (with their division into "management" and "economic" entities), introducing the competitive placement of state contracts for protection, conservation and regeneration of forests. Powers related to forest conservation (Fire Safety Supervising Agency in forests, government supervision and monitoring in the forests of the Moscow region, supervision over the exercise of powers which were granted by constituent entities of the Russian Federation) were granted to the Federal Veterinary and Phytosanitary Monitoring Service, which did not have the necessary personnel. In most inhabited localities, where the enterprises of the forest-based sector were the main employers, there was a sharp increase in unemployment and a fall of living standards.

The fires in summer of 2010 revealed the unpreparedness of forestry to fire hazard. An urgent response was needed, as was prescribed by Federal Laws No. 167 of July 22 and No. 442 of December 29, 2010, which established requirements for preventive action aimed at detecting factors that cause the development of forest fires and mitigating the risks of forest fires; the norms of mandatory monitoring of forest fires and fire hazard in forests were introduced. Much attention was given to ensuring health and radiation safety, as well as emergency recovery.

The history of forestry legislation reforming is dramatic—it is focused on every possible utilization of forest resources of Russia rather than conserving them. It stands to reason that the issue of legal regulation of forest use and conversion of forest land to other kind is covered in the norms of the Land Code of the Russian Federation "The boundaries of forest lands are defined in accordance with: 1) land legislation; 2) forestry legislation; 3) urban development legislation" (Dubovik 2009).

Allocation of protective forests, which include forests within specially protected natural areas, forests located within water conservation zones; forests which function for the protection of natural and other objects, can be considered to be a conservatory measure; as well as valuable forests (Article 102 of the Forestry Code of the Russian Federation). The Code also identifies designated forest plots: coast-protective, soil protective, located along water bodies or hillside gullets; forest margins bordering the treeless areas; seed plantations, constant seed plantations and other objects of forest growing seed; reserve forest plots; forest plots with relict and endemic plants; habitats of rare and endangered species of wild animals; natural heritage assets; other designated forest plots as specified in the Forest Management Regulation (Article 119 of the Forestry Code of the Russian Federation). A special regime is introduced in the forests of abovementioned categories, prohibiting clear felling, as well as sanitary measures aimed at protecting plantation from pests and diseases. However, most of these requirements remain on paper: any economic activity is considered to be top-priority compared to the conservation of even the most valuable forest ranges (Mayorova 2016a).

Amendments which come down to the expansion of types of permitted use of land plots, as well as types of feasible construction, are constantly introduced to Federal Law "Concerning Specially Protected Natural Areas" (SPNA). Within many SPNA, pursuant to Federal Law "On Introducing Amendments to Federal Law "Concerning Specially Protected Natural Areas" and certain legislative acts of the Russian Federation" of December 28, 2013 No. 406-FZ, the forms of forest use are practiced that are prohibited by their regime and leading to the destruction of the natural complexes for the preservation of which these SPNA were created. The current concept for the development of the system of SPNA of federal significance for the period until 2020, as well as the plan of action to implement the Concept (http://forestforum.ru/viewtopic.php?f=9&t=11058) envisages the development of a chain of mini-hotels and guest houses (say cottages). Paragraph 43 of the Concept implementation plan provides for the development of a package of excursion programs for every wildlife reserve and national park. This creates a legal framework for the involvement of wildlife reserves (including those that fall within the limits of world heritage plots) in intense tourism activities and site development of their territory by recreational facilities. Federal Law No. 406-FZ "On Introducing Amendments to Federal Law "Concerning Specially Protected Natural Areas" and certain legislative acts of the Russian Federation" of December 28, 2013 offers the possibility to convert almost any wildlife reserve into national park. However, within the territory of national parks (except preserved area and specially protected natural area), one may build recreational, tourism and sports facilities as well as related infrastructure without any additional permit (in accordance with the previous edition, it required a Decree of the Government of the Russian Federation), as well as any objects (including line infrastructure) to ensure the functioning of inhabited localities within the boundaries of national parks.

As for the national park "Losiny Ostrov", this means that virtually any objects may be built within its territory (which is actually taking place at present), since this park is included in Moscow. http://www.forestforum.ru/oopt.php?str=7. As for flora outside of forests—landscaped urban areas and vegetation of urban SPNA—it is even more vulnerable than forest reserves. Article 85 of the Land Code of the Russian Federation points out that lands of inhabited localities serve as a spatial basis for the accommodation of residential, social, business, industrial, recreational and other infrastructure facilities.

Urban plantation, despite adopted laws on their protection and conservation—for example, Law of Moscow City No. 17 “Concerning the protection of landscaped areas” of May 5, 1999 (as amended on 07.05.2014)—often fall prey to expansive site development, motorway laying, renovation, construction of cult facilities etc. The Urban Development Code of the Russian Federation and particularly regulations of this branch of legislation slightly limit the possibility of site development of landscaped areas (Mayorova 2016b).

Deforestation and destruction of other landscaped areas result in reduced biodiversity. This is largely relevant to fauna, which, pursuant to Federal Law “Concerning Fauna”, shall be understood to mean wild animals in the state of natural freedom. Domestic animals, just like captive wild animals, are not included with fauna.

The issue of forms of ownership of fauna, as well as the system of norms governing its protection, use and restoration, is of particular importance in faunal legislation. The use of fauna is regulated by the legislation in several directions, the main ones being hunting and fishing. The document regulating hunting is Federal Law No. 209-FZ “Concerning Hunting and the Preservation of Hunting Resources” of 24.07.2009. Agricultural land and forest land are considered as hunting areas. Several designated groups of animals are huntable: ungulates, fur-bearing, bears, and birds. Law No. 26-FZ “On Introducing Amendments to Federal Law “Concerning Hunting and the Preservation of Hunting Resources and on introducing amendments to certain legislative acts of the Russian Federation” of February 18, 2020 and Federal Law “Concerning Fauna”, which is unofficially dubbed “On aviary hunting”, permitted to create fenced areas and other hunting infrastructure facilities within forest plots in order to breed, manage and subsequently hunt animals. This law drew a negative response of society, especially among zoologists and biologists. In addition to strong moral condemnation of the paid killing of animals, scientists warn us of consequences for the environment: all plant populations within fenced areas will be harmed, predators such as bobcats and wolves will be eliminated. More than 400,000 people signed a petition against aviary hunting. While this type of hunting has been legalized, the regular rejection of the draft law on animal cruelty no longer seems to be perplexing. Such a law could limit the rights of sport hunters taking pleasure from the murder of defenseless “dumb animals” (Boreiko 2016).

Fishing is regulated by a special framework act—Federal Law No. 166-FZ “Concerning fishing and conservation of aquatic biological resources” of December 20, 2004, as well as Decrees of the Government of the Russian Federation, e.g. Decree No. 395 of 31.03.2017 and Decree No. 324 “On Introducing Amendments to the national program of the Russian Federation “Development of the fisheries industry” of 27.03.2019 et al.

Free fishing for all declared in the law is rather a figure of speech. Fishing without any reservations is only permitted within shared facilities, i.e. in water bodies located on State and municipal lands not leased to third parties and not having the status of privileged access thereto; the concept of daily quota is introduced, in other words, the amount of aquatic biological resources that is allowed to be caught during a calendar day; in other words, the scale and the pattern of personal consumption by the population are rationalized in the field of fishery. These norms are designed to conserve aquatic biological resources of the country, which have been severely depleted due to indiscriminate industrial-scale catching and poaching (Bardanov 2011).

Human awareness of the danger of the loss of populations of many animal and plant species has resulted in the creation of a special document—the Red Book of the Russian Federation. This is reflected at the legislative level in Article 60 of Federal Law "On Environmental Protection" as well as in Articles 4, 6.1 and 24 of Federal Law "Concerning Fauna", which prescribe creating the Red Book of the Russian Federation and Red Books of constituent entities of the Russian Federation in order to protect and record rare and endangered species of plants, animals and other organisms. Species that are listed in Red Book shall be exempted from economic use. Activities that are conducive to the reduction in the number of these organisms and deterioration of their habitats are prohibited.

The president of the Russian Federation became concerned about the conservation of endangered species: Amur tigers, panthers, polar bears, whales, octopuses and ringed seals—and took over the leadership of a number of programs to conserve and restore them. The red-listed Amur Tiger and Amur leopard became the best known of them thanks to the interest of the head of the State. In 2012, the national park "Zemlia Leoparda" was established, and in 2013 Russian Geographical society-initiated creation of the Specialized Center "Amur Tiger" (https://www.newsru.com/russia/11oct2013/leopard.html). However, the list of endangered species is much broader.

The existence of populations is inextricably connected to the conservation of their natural habitats. Forest clearance, ploughing and site development of land, river diversion, water pollution and other negative man-made impacts on the natural habitat will inevitably lead to a reduction in the biodiversity of nature of the country. Still, we should hope that amendments to the Constitution of the Russian Federation of July 1, 2020 obliging the Government of the Russian Federation to "implement measures aimed at the conservation of unique natural and biological diversity of the country", as well as "to form a responsible attitude towards animals in society" will play a transformative part in the worldview of Russians and in improving the overall environmental situation.

4 Conclusions and Recommendations

To summarize the above, the following should be noted. The market-based, consumer attitude to the country's natural wealth has resulted in the fact that environmental legislation failed to achieve proper degree of elaboration and flexibility of regulatory mechanisms of environment-oriented relations, contributing to conservation and restoration of natural resources. This is also proved by a vast number of amendments that are introduced to environmental acts, aimed at even more intense introduction of environmental items.

In order to avoid the impending depletion of natural resources, it is advisable that the State and the makers of environmental legislation:

- Abandon the ideology of "economic advance at the expense of environmental regression".
- Orient the process of natural management to the underlying principle of sustainable development: "we must return to succeeding generations what we have received from previous generations".
- Correct the distorted worldview that has arisen in the context of market conditions, fill the gaps in the environmental legal awareness.

In order to change the paradigm of a man's attitude to nature, understand the nonseparability of their relationship, to create a system of continuous, step-by-step improvement of environmental education, formation of environmental culture. The idea of the unity of man and nature, the common living space of the Earth should constitute the basis of environmental ethics and environmental ideology.

These goals include the space for joint activity of public authorities, educational institutions, mass media, non-governmental associations, and all citizens.

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Prosecutorial Supervision in the Field of Environmental Protection and Rational Use of Natural Resources: Modern Historiography of the Problem

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1 Introduction

Currently, in the Russia, specialized state institutions play a special role in environmental protection. The most important place among these institutions in Russian Federation belongs to the prosecutor's office. Supervision of the implementation of environmental protection laws and nature management is one of the main areas of prosecution authorities' activity in Russia.

We will analyze the scientific works of the contemporary domestic researchers in which the features and some aspects of prosecutorial supervision in the field of environmental protection are identified and carefully studied. We will pay special attention to fundamental works, primarily dissertation research, written by Russian theoretical lawyers in recent years on the basis of the current regulatory framework of the Russian Federation in the field of environmental law.

2 Methodology

When writing this paper, we used both general scientific and historical research methods. Among general scientific methods, comparison, generalization, analysis, and synthesis are necessary to highlight. Among specialized methods, comparative-historical and historical-typological methods should be singled out. The comparative historical method allows one to study historiographic facts in close connection with the historical background, as well as to monitor

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their qualitative change at various stages of their development. The historical-typological method allows one to split and group sources according to the researchers' views on a given aspect of the subject under the study.

3 Results

The historiography of the current problem is represented by the individual monographic and dissertation works, as well as by a number of scientific articles. Almost all of these studies were conducted by lawyers: both scientists and practicing prosecutors.

The scientific works on the subject of "Prosecutorial supervision in the field of environmental protection and the rational use of natural resources" can be divided into three groups: (1) studies with a broader focus on the features of prosecutorial supervision in the field of environmental protection in general; (2) studies with a narrower focus, devoted to particular aspects of prosecutorial supervision of a specific object of environmental law (protection of atmospheric air, protection of forests, disposal of production and consumption wastes, etc.); (3) scientific works devoted to the environmental policy of the state, in which special attention is paid to the prosecution authorities' activities in the field of environmental protection.

The works of the following authors represent the first group of the scientific studies: E. V. Kurilova, O .A. Pustovalova, A. A. Darbinyan, Ya. B. Ditsevich, L. M. Balakireva, O. A. Teslenko, etc.

Thus, in the dissertation written by E. V. Kurilova, "Legal and Organizational Fundamentals of Prosecutorial Supervision of the Execution of Legislation on Administrative Responsibility in the Ecological Environment", the author studies the domestic prosecution authorities' activities on the organization and implementation of prosecutorial supervision of the enforcement of legislation on administrative responsibility in the field of ecology. The legislation governing the supervision of prosecutors is also analyzed (Kurilova 2014, p. 8). In the framework of the research, E. V. Kurilova reveals a number of shortcomings in the activities of prosecution authorities monitoring the implementation of legislation on administrative responsibility in the ecological environment: (1) errors in the selection, placement and training of personnel; (2) miscalculations in workload forecast and planning and in the distribution of the responsibilities; (3) errors in the adoption, implementation, and management decisions monitoring, as well as in verification of their performance (Kurilova 2014, p. 186).

In terms of this, it is not surprising that this researcher offers a number of recommendations for improving the legislative framework of the Russian Federation on administrative responsibility in the ecological environment with regard to the organization and implementation of prosecutorial supervision. According to E. V. Kurilova, the improvement of the supervisory activities of the prosecutor's office in the field of ecology can be facilitated by: public education in the form of analytical reports, reviews, publications and media spots covering administrative sanction cases for violation of environmental laws; methodological support for the supervision and verification of the implementation of legislation on administrative responsibility in the field of environmental protection; improving the quality of analytical work to identify the prerequisites and causes of violations of the legislation in the field of ecology (Kurilova 2014, p. 200).

O. A. Pustovalova in her dissertation "Improving the prosecutor's supervision over the implementation of environmental legislation" examines the problems associated with ensuring the effectiveness of the implementation of the powers of prosecutors when exercising supervision over the implementation of environmental legislation at all stages of the supervisory process, and also identifies the most effective forms and methods of work of prosecutors to strengthen the rule of law in this area. This author, on the pages of his research, draws special attention to the fact that the acts of the prosecutor's response often do not indicate the reasons for violations of environmental legislation, there are no references to regulatory legal acts that have been violated, and specific violators of the law are not always named (Pustovalova 2011, p. 182). In order to improve the quality of prosecutorial supervision of the implementation of environmental legislation, O. A. Pustovalova suggests: (1) to legally oblige prosecutors to participate in preventive work; (2) to remove the existing restrictions on the right of the prosecutor to file lawsuits with arbitration courts and courts of general jurisdiction in defense of individuals and legal entities (Pustovalova 2011, p. 229).

In his dissertation work, A. A. Darbinyan "Prosecutor's supervision over the legality of legal acts issued by the Ministry of Natural Resources and Ecology of the Russian Federation and federal bodies subordinate to it" examines the features of legal relations arising in the course of prosecutorial supervision over the legality of legal acts issued by the Ministry of Natural Resources and Environment of the Russian Federation (Darbinyan 2013). The work of the mentioned above author is focused on the following key areas of increasing the effectiveness of prosecutorial supervision of the legality of acts issued by the Ministry of Natural Resources of Russia and its subordinate bodies: (1) increasing the effectiveness of the interaction of prosecutors with heads of federal and regional authorities in the field of environmental protection; (2) improving the methodological base of prosecutorial supervision of the legality of legal acts in the field of ecology; (3) improving the quality of the development of private methods for inspecting the legality of acts in the field of nature conservation at specific objects (Darbinyan 2013, p. 206).

Researcher Ya. B. Ditsevich in the monograph "Actual directions of activity of prosecution authorities in the field of environmental protection" considers the main issues of organizing prosecutorial supervision in the field of environmental protection, and certain aspects of the implementation of supervisory activities in relation to various environmental components. He pays special attention to the main areas of the prosecutor's office's activities in the field of protection of forests, water, the atmosphere, land and wildlife (Ditsevich

2017). Ya. B. Ditsevich supports the initiative to create specialized judicial bodies in Russia, along with specialized structures within the internal affairs bodies and prosecutors, for the consideration of criminal and civil cases of an environmental nature (environmental courts). However, at the same time, the researcher recognizes the fact that at present in the Russian Federation it is more realistic to establish specialization when considering cases of such category by individual judges in the framework of the activity of courts of general jurisdiction (Ditsevich 2017, p. 44). Ya. B. Ditsevich is also convinced that due to the length of time to eliminate the consequences of violations in the field of environmental protection and the need to allocate significant funds to solve environmental problems arising from the commission of environmental offenses, it is important to enhance the application of the prosecutor's authority granted to him/her by law to appeal to the judicial authorities with claims for compensation for harm caused to the environment, as well as the organization of systematic supervision of the execution of judicial decisions on claims brought by the prosecutor's office (Ditsevich 2017, p. 171).

In their article "Prosecutorial Supervision in the field of environmental resources management", L. M. Balakireva and O. A. Teslenko express the idea to create a unified system of environmental prosecutor's offices in Russia, which in turn will make it possible to organize a new prosecutorial supervision in the field of ecology in our country. The creation of such system will ensure the complex and consistent work on the prevention and suppression of environmental offenses (Teslenko and Balakireva 2017, p. 182). These researchers also express the idea that in order to improve the practice of prosecutorial supervision in the field of environmental protection it is advisable to constantly inform the public about the measures to counter environmental safety offenses via print and electronic media, radio and television (Teslenko and Balakireva 2017, p. 183).

The scientific works of the second group are represented by the research of the following legal scholars: E. Yu. Shersneva, M. N. Miroshnichenko, M. M. Kakitelashvili and others. Thus, for example, E. Yu. Shersneva in her dissertation "Prosecutorial supervision of the implementation of forest conservation and protection laws" explores the features of legal relations that are developing during the work organization and prosecution authorities' supervision of the forest conservation and protection laws implementation (Shersneva 2014). This researcher draws the reader's attention to the fact that environmental prosecutor's offices have not been established, and are not functioning in all regions of Russia. Moreover, E. Yu. Shersneva is convinced that such offices should appear in all regions of our country (Shersneva 2014, p. 126). This legal scholar offers the prosecution authorities to establish close cooperation with environmental public organizations through joint "round tables", seminars and conferences. E. Yu. Shersneva also advocates restoring the institute of public forest inspections, which, in her opinion, will decrease burden put on the relatively few forest protection staff (Shersneva 2014, p. 140). According to the researcher, the use of powers by prosecutors in supervising the implementation of laws on the protection of forests should first of all have a preventive focus. Therefore, according to E. Yu. Shersneva, prosecutors should more actively use such tools of prosecutorial response as protest and warning (Shersneva 2014, p. 152).

M. M. Kakitelashvili in his article "Prosecutorial supervision of the implementation of laws in the field of forest protection from fires" notes that "the work of prosecution authorities to implement laws on ensuring fire safety in forests is one of the priority areas of activity of the Russian prosecutor's office" (Kakitelashvili 2018, p. 76). According to this scientist, in resent decade the activities of the prosecutor's office have contributed not only to weakening, but also to eliminating the circumstances that determine the commission of offenses in the field of protecting forests from fires. The prosecution authorities have a special role in improving legislation in the field of forest protection from fires, providing legal education of the population through media, and also publishing scientific and methodological works on forest protection issues (Kakitelashvili 2018, pp. 78, 79).

In another publication "The legal status and prosecutorial supervision of the implementation of laws on the protection of the atmosphere in the Russian Federation" M. M. Kakitelashvili focuses on the fact that prosecutorial supervision of the implementation of legislation on the protection of the atmosphere is aimed primarily at ensuring compliance by all legal entities with the requirements of Russian legislation in the field of the atmosphere protection in order to improve the quality of the atmosphere and prevent its harmful effects on health (Kakitelashvili 2016, p. 147). According to M. M. Kakitelashvili, in a significant number of cases, measures to eliminate violations of legislation on the protection of the atmosphere in our country were taken by legal entities only after the prosecution authorities' intervention.

Another lawyer M. N. Miroshnichenko, in one of his articles considers and analyzes the objectives of prosecutorial activity in the field of land use and protection in the industrial region (Miroshnichenko 2015, p. 58). M. N. Miroshnichenko also advocates the development and adoption of the Federal Law "On the Protection of Land in Industrial Regions" in Russia. According to this legal scholar, in this legal act, a separate section on the organization and implementation of the activities of the prosecutor's office to ensure the enforcement of legislation on land protection in industrial regions should be elaborated (Miroshnichenko 2015, p. 60).

The studies of the following authors refer to the works of the third group: Yu. S. Prikhodko, N. Suslova, D. Dobretsov, E. K. Kujeva and others. In one of the sections of his thesis "Environmental policy of the state in the north of Western Siberiain the second half of the twentieth—early XXI centuries" Yu. S. Prikhodko pays special attention to the role of prosecution authorities in environmental protection in the second half of the twentieth—early XXI century. According to Yu. S. Prikhodko, in the late 1980s in the Soviet Union, the effectiveness of prosecutorial supervision was significantly reduced by the existing state policies concerning the development of natural resources. The psychology of a "temporary worker", that is, the conquerors of nature were forgiven much, reigned for a long time in the USSR (Prikhodko 2015, p. 173). The insufficient staffing of the prosecutor's office in the midst of a constant increase in the number of environmental offenses and the lack of effective legal tool applied to violators of the law in this area were the constraining factors for the development of the environmental protection system in the late 1980s and early 1990s. According to this researcher, in the 1990s the role and importance of prosecution authorities in the field of environmental protection, seems to increase significantly, and district environmental prosecutor's offices are established in some regions of Russia (Prikhodko 2015, p. 174).

N. Suslova and D. Dobretsov in their article "Ensuring the rule of law in the field of environmental protection" note that in the twenty-first century, prosecutors pay great attention to ensuring the constitutional right of citizens of our state to a favorable environment. According to these authors, supervision over the implementation of laws by controlling environmental authorities, authorities and supervision over the implementation of legislation on the protection and use of water bodies, on industrial waste, in the field of forest management, subsoil use, on the protection and use of aquatic biological resources, is currently a priority in the work of the domestic prosecutor's office (Suslova and Dobretsov 2010, p. 52).

In the article "The activities of law enforcement and environmental authorities in the area of prevention of environmental crimes" E. K. Kujeva analyzes the problems of the activities of law enforcement agencies (internal affairs bodies, courts, prosecutors) in the field of protecting natural resources and preventing crimes against the environment. According to E. K. Kuzheva, a key link in the state mechanism for overseeing the implementation of environmental legislation and the fight against environmental crimes in Russia is the prosecutor's office, which monitor the implementation of environmental legislation by government institutions (regional and federal levels) (Kujeva 2019, p. 88). That is why, according to the author, any steps aimed at weakening prosecutorial supervision in the field of ecology should be regarded as extremely negative.

4 Conclusions

In conclusion, it should be noted that in the 2010s. In Russia, a fairly large number of scientific works, including dissertations, have appeared on various aspects of prosecutorial supervision in the field of environmental protection. In these studies, their authors presented the theoretical and methodological foundations for the organization and implementation of prosecutorial supervision over the implementation of legislation in the environmental sphere. As a result, this kind of scientific works of lawyers devoted to various aspects of prosecutorial supervision in the field of environmental protection, in fact, turned into one of the most important tools for increasing the efficiency of prosecutorial supervision in the field of environmental safety.

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Digital State-Public Monitoring and Management of Environmental Protection Processes in the Region in Industry 4.0: High-Tech Approach to Security

Mikhail Yu. Zakharov, Liliya A. Kripakova, Murat A. Bulgarov, and Maria E. Konovalova

1 Introduction

Environmental protection issues have been actively addressed in recent years in connection with the adoption of sustainable development goals, especially at the regional level, where the causal links of economic practices are most clearly identified and climate change and signs of environmental disasters are directly felt. But the established practices of regional monitoring and management of environmental protection processes are characterized by a number of shortcomings.

Firstly, the existing hierarchy of monitoring participants implies a clear distinction between monitoring entities—public administration bodies in the region—and monitoring facilities—regional entrepreneurship entities and the regional community. Because of this distinction, economic entities perceive monitoring negatively—as a measure of control and seek to circumvent it, and

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are also excluded from participating in monitoring and cannot provide information support to state environmental supervision and management in the region.

Secondly, there is a lack of transparency of environmental monitoring results in the region. State regulators do not publish detailed reports on their environmental regulatory activities. Individual fragments of monitoring results are published in corporate reporting and media materials. Therefore, stakeholders lack a holistic understanding of the state of the environment in the region and the environmental sustainability of environmental management practices.

Thirdly, information support for monitoring and management of environmental protection processes in the region is incomplete due to the limited production capacity of state supervisory authorities. This updates the issue of improved monitoring and management of environmental protection processes in the region.

The hypothesis of this study is that it will be possible to ensure the environmental safety of the region by taking advantage of the capabilities of industry 4.0. The purpose of this study is to develop a high-tech approach to ensuring security based on digital state-public monitoring and management of environmental protection processes in the region in industry 4.0 and to justify its applicability using the example of Russian regions.

2 Literature Review

The current practice of monitoring and managing environmental protection processes in the region is discussed in the works of scientists such as Inshakova et al. (2020a, b), Popkova et al. (2021), Popkova and Sergi (2019), Tarakanov et al. (2020). The specifics of leveraging industry 4.0 in the practice of public administration in the region in organizing the e-government system are disclosed in the works of researchers such as Bogoviz (2020), Bogoviz et al. (2020), Chohan et al. (2020), Dias (2020), Gupta and Maurya (2020), Kaya et al. (2020).

At the same time, the foundations and prospects for digital state-public monitoring and management of environmental protection processes in the region in the 4.0 industry are not defined, and a high-tech approach to ensuring environmental safety in modern regions is not formed. This research is being conducted to fill these gaps.

3 Materials and Method

In order to identify the prospects for digital public-public monitoring and management of environmental protection processes in the regions of Russia in the 4.0 industry and to determine the possibilities of introducing a high-tech approach to ensuring safety, the regression dependence of the environmental, industrial-ecological and socio-ecological index on the quality of public services in electronic form is determined.

Table 1 Environmental indices and the quality of public services in electronic form in the top 10 regions of Russia in terms of the level of development of e-government in 2020

Region	*Quality of public services in electronic form, points 1–100*	*Nature index, points 1–100*	*Industrial and environmental index, points 1–100*	*Socio-ecological index, points 1–100*
Moscow	87.81	33	70	84
Moscow Region	85.37	32	34	75
Tula Region	85.32	40	37	68
Smolensk Region	83.17	51	49	71
Rostov Region	81.45	46	57	741
Novosibirsk Region	80.42	47	50	64
Stavropol Territory	79.49	58	44	69
Belgorod Region	79.20	62	62	83
Kamchatka Territory	76.21	56	41	70
Udmurt Republic	75.35	53	52	78

Source Compiled by the authors on the basis of materials D-Russia (2021), Green Patrol (2021)

Positive regression dependencies will reveal those areas of environmental monitoring that are amenable to digital modernization in the regions of Russia. For the study, the top 10 regions of Russia were selected for the level of development of e-government (quality of public services in electronic form) in 2020 in accordance with the D-Russia rating (2021). Data for these regions are shown in Table 1.

4 Results

In accordance with the materials from Table 1, regression dependencies were identified (Figs. 1, 2 and 3), showing the possibility of extending digital public-public monitoring and management of environmental protection processes in the region in the conditions of the industry 4.0 to different areas of environmental protection in the top 10 regions of Russia in terms of the level of development of e-government in 2020.

According to Fig. 1, the development of e-government in the regions of Russia does not even have a neutral, but clearly negative and pronounced impact on environmental protection. Therefore, the improvement of the general state of the environment not related to economic environmental

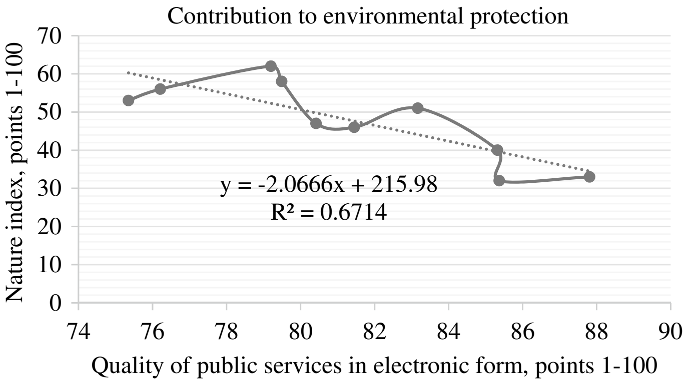

Fig. 1 E-government contribution to the environment (*Source* Calculated and built by the authors)

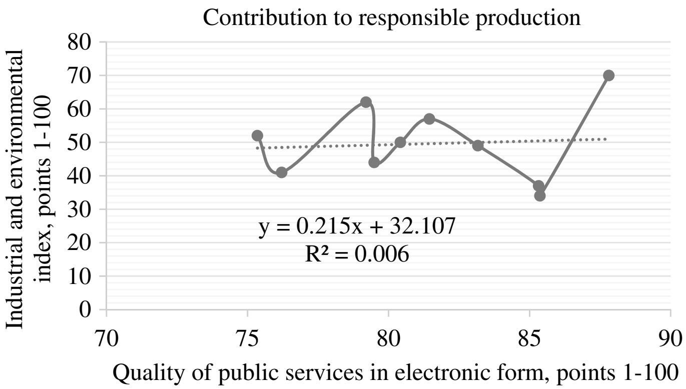

Fig. 2 E-government contribution to the environment (*Source* Calculated and built by the authors)

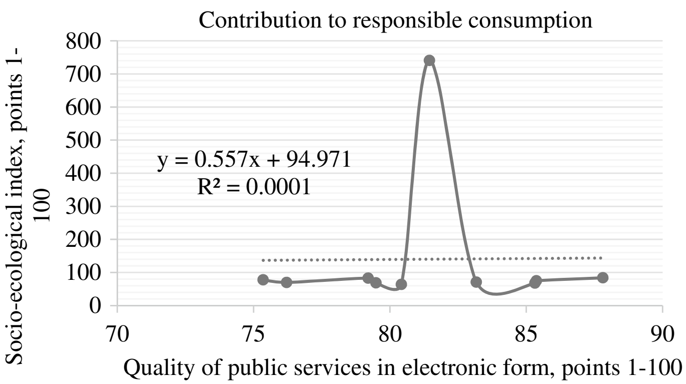

Fig. 3 E-government contribution to the environment (*Source* Calculated and built by the authors)

management (production or consumption) is not available in Russia based on the capabilities of industry 4.0.

Figure 2 shows that the development of the e-government system by 1 point in the regions of Russia increases production responsibility by 0.215 points.

Figure 3 shows that the development of the e-government system by 1 point in the regions of Russia increases consumption responsibility by 0.557 points. Based on the established positive regression relationships, responsible production and consumption practices are included in the proposed high-tech approach to security based on digital public-public monitoring and management of environmental protection processes in the region in industrial conditions 4.0 (Fig. 4).

Figure 4 shows that the proposed approach implies a hierarchical system of state-public monitoring and management of environmental protection processes in the region in industry 4.0. But the electronic government of the region is no longer at the top, but is located on the same level as digital regional entrepreneurship and the information society of the region. This allows us to build trust between them and establish their joint state-public monitoring of practices of responsible production and consumption in the region (lower tier of the pyramid).

All monitoring materials are transferred to the top of the pyramid—to an independent and open blockchain platform. E-government carries out its intellectual analytics and uses its results in state environmental management.

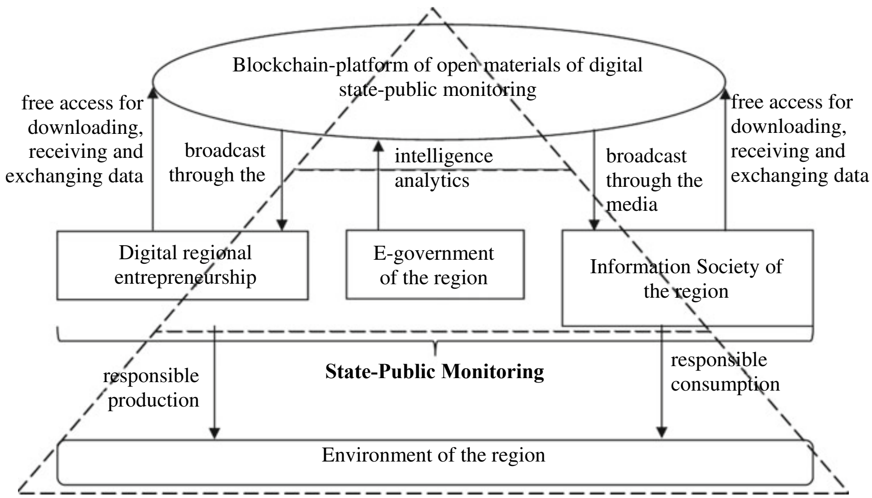

Fig. 4 High-tech approach to security based on digital state-public monitoring and management of environmental protection processes in the region in industry 4.0 (*Source* Calculated and compiled by the authors)

Entrepreneurship and society have free access to the platform for downloading, receiving and sharing data, which is also broadcast through regional media.

5 Conclusion

In the conclusion we need to note that digital state-public monitoring and management of environmental protection processes in the region in the industry 4.0 in Russia should focus on responsible production and consumption, but it should not cover other environmental management, since the possibilities for its optimization using e-government are limited and contradictory.

The developed high-tech approach to security based on digital public-public monitoring and management of environmental protection processes in the region in the industry 4.0 provides the following advantages:

- Involve all stakeholders in the monitoring process to collect the most complete and reliable information on the state of the environment in the region and regional practices of responsible production and consumption;
- Full transparency of the results of environmental monitoring in the region, allowing business entities to reasonably decide on cooperation or non-cooperation with enterprises and consumers with different ecological reputations, which makes it possible to intensify the market mechanism in the environmental sphere;
- Better information support for public administration in the region, allowing for more informed administrative decisions and the coverage of more environmental management practices.

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ICT Governance and ESG Factors: A New Agenda for the Boards of Directors

Alexander S. Yukhno

1 Introduction

Responsible investing is becoming one of the main trends in capital markets in the twenty-first century, along with interest in information and communication technologies and green energy. In the context of the transition to digital economy, the board of directors of a company needs to identify emering trends and risks and determine their relevance to a company.

On January 1, 2016, 17 sustainable development goals (SDGs) came into effect. They are set out in the 2030 Sustainable Development Agenda that was approved by the global leaders in September 2015 during the historical UN Summit in Paris. The amount of investment in the companies complying with the ESG principles[1] in Europe has been growing by a third every two years from 2014 to 2018 (PwC 2019). In this context, continuous transformation of the company governance becomes one of the main objectives of the board of directors (hereinafter also BoD), as digitalization is a never-ending process that does not allow simply setting out uniform principles and approaches just once. It is not a surprise that given the ever-increasing demand to make ICT investment more efficient, their governance, most often being one of the

[1] Care for the environment, social well-being and a responsible approach to corporate governance form the so-called ESG (environmental, social, governance) factors.

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most vulnerable elements of the organization's corporate governance, started gaining increasing attention (Brown and Grant 2005).

The purpose of this research is to understand how information and communications technologies can help to address tasks related to environment protection and successfully integrate these solutions into the corporate governance objectives.

2 Methods

The research is based on the analysis of the scientific and practical sources in the field of ICT and ESG governance. The statistical studies and open sources of information on practical aspects of ICT and ESG governance were used to identify the main trends in the use of ICT and the role of the board of directors in ESG risk identification. The empirical and comparative analysis, expert assessments, synthesis, deduction, and induction were applied in order to form the guidance for the BoD to provide the right governance for a company.

3 Results

Lack of ICT governance and commitment to ESG principles exposes a company to significant risks (in particular, by causing losses, higher operational expenses, higher cost of borrowed capital, undermining a company's reputation, poor experience of introducing innovations, etc. [IT Governance Institute 2003]) which, in their turn, may prevent a company from achievement of its strategic goals (Nolan and McFarlan 2005). The BoD shall play the pivotal role in setting up the ICT governance and ESG integration in the business strategy. However, the current corporate practice shows that due to various reasons the BoD does not always manage to give due consideration to the matters related to technological development (Peregrine 2015), while ICT issues are not top priority topics for discussions at its meetings despite—sometimes significant—investment and serious associated risks. ISACA identifies the following reasons for these issues:

- The need for greater technical knowledge than on other items on the agenda;
- Look at ICT as a separate matter from the enterprise's business;
- The complexity of the topic, especially for enterprises operating in the network economy (IT Governance Institute 2003).

According to the results of PWC's Russian Boards Survey in 2018, BoD oversees technology adoption only in 7% of companies. In the other companies, it falls within the competence of the management. Another challenge is that 57% of BoD members meet with the Chief Information Officer once or twice a year, which is not consistent with the emerging international practice of having such meetings on a regular basis. The survey authors' recommendation to BoD members is to improve their digital competence, define their technology priorities and incorporate them into strategic governance as well as to assign persons responsible for cybersecurity risk control (PwC 2018). This practice is a concern since the board of directors is the key governance body in terms of incorporating ICT in the company activities as well as overseeing ICT risks within the company's overall risk management system.

ESG risk management should become one of the key topics on the agenda for the board of directors. In light of the events that had a critical impact on development of the company strategies in health, safety and environment (HSE) (explosion of oil platform Deepwater Horizon in the Gulf of Mexico at the Macondo field in 2010 and diesel spill in Norilsk), the focus of the board of directors is gradually shifting towards environment protection. In both cases, the accidents caused significant damage to flora and fauna, and the companies responsible for them paid record billion dollar fines.

To make HSE risk management more efficient as well as to demonstrate commitment to ESG, the board of directors should pay attention to digitalization opportunities when developing long-term development strategies. Technology solutions can mitigate risks and contribute to decision-making and resource distribution. A number of technologies can already be widely applied for HSE risk management:

- Software enablement and advanced analytics: collect larger HSE data points to calculate better performance indicators to meet corporate and regulatory requirements, while anticipating and mitigating risks, and identifying opportunities to reduce incidents and improve productivity.
- Virtual reality: improve training effectiveness by providing organizations with a high-impact, scalable and efficient method to rapidly build the capabilities of workers—particularly those with less experience in high-risk environment.
- Drones and robotics: perform typically dirty and dangerous jobs by accessing areas that are difficult to reach, such as those collecting data from inaccessible areas of legacy mines for remediation efforts. This technology can also be used to significantly reduce time performing things such as large site scans or map areas of cultural heritage close to the mine (Millet 2020).

Statistically, many BoD members overseeing ICT do not have the required technical and professional knowledge and competences (Deloitte 2017). According to the 2019 National Corporate Governance Index research, in Russia's 100 largest public companies quoted on the Moscow Stock Exchange, only 3% of the BoD members have expertise in IT, innovations and digital technologies, with the average number of board directors having relevant competences being one (Top Competence 2019). Therefore, sometimes that lack of understanding of ICT governance issues may prevent them from duly performing their duties.

While recognizing that BoD members periodically have to deal with ICT issues, it is important for them not to be overwhelmed with technical details. First of all, they need to identify what is the impact of ICT on strategic business development and monitor the consequences of ICT use by the company. At the same time, companies have to understand what level and scope of ICT expertise is needed for the company's BoD and management performance.

In the context of swift technological transformations, active involvement of the BoD in ICT governance and oversight over emerging risks become a key to responding to the ongoing technological changes. There appears to be no universal model for ICT governance by the BoD. A balanced approach would require taking into account a variety of factors (Nolan and McFarlan 2005). One should agree that all companies have ICT governance in place, in varying degrees. The only difference between them is that companies that do it efficiently have developed and implemented a set of mechanisms for such governance (board of directors committees, relevant organization chart, to name a few) and encourage behavior that corresponds to the enterprise mission, strategy, values, standards and culture (Weill 2004).

To ensure efficient ICT governance, PwC developed an IT Oversight Framework that represents a six-stage process:

1. Assess the role of information technologies for the company (state of IT infrastructure, IT budget, importance for business model and expected changes from the implementation of information technologies, etc.);
2. Define who will control and monitor the use of IT within a company (BoD, a BoD committee) and whether all the necessary resources are available;
3. Set IT priorities within a company;
4. Define what place IT priorities take in the company's overall business strategy;
5. Integrate IT risks in the company's overall risk management process;
6. Continuously monitor the company's IT development (Cloyd 2013).

Once the relevant approaches are defined and agreed, the development of relevant corporate strategy may begin. For instance, the IT Governance Institute breaks down BoD's IT governance into five domains:

1. IT strategic alignment—aligning the company's business and IT strategy enabling to accomplish strategic goals and business objectives;
2. IT value delivery—optimizing the costs and the added value delivered by IT;
3. IT risk management—addressing IT security, understanding the risks and managing them;

4. IT resource management—optimal investment, use and allocation of IT resources (people, applications, technology tools, data) when catering for the needs of the company;
5. Performance measurement—developing and monitoring strategy implementation and IT services (IT Governance Institute 2003).

IT strategic alignment, resource management and performance measurement are seen as the drivers for such activity, with value delivery and risk management as the results. It is noted that most models, structures and standards for ICT governance take these five main areas into account when dealing with IT implementation (Aasi et al. 2017).

As a part of their role as the guardian of long-term corporate performance, boards have a key role in ensuring that companies are aware of, and able to navigate, an ever-evolving risk landscape. Where ESG risks impact—or may impact—the business, it is their duty to exercise risk-related oversight.

Effective ESG risk management can be achieved by the board using the recommendations in Table 1.

Boards need to be able to understand how to oversee ESG risks through their overall oversight of the risk identification, prioritization and mitigation processes using IT. Boards also need to understand how to adequately structure and disclose their ESG oversight to investors and other stakeholders through application of effective IT Governance (Ramani and Saltman 2019).

Since ICT becomes an increasingly important tool for maintaining the organizational resilience of enterprises, it is imperative that the level of corporate governance and the agenda of board meetings are in line with the ongoing changes in terms of the strategy and the improvement of the company's competitiveness (Peregrine 2015) as well as ESG issues. The time between 2010 and 2015 demonstrated that security-related issues (cybersecurity, data confidentiality, etc.) remain the main information technology topics discussed by the boards of directors. A more proactive approach to examining the implications of technology adoption could provide more space in the activities of the board of directors for discussions about technology-related business opportunities and digitalization of the company as a whole (Deloitte 2017). To help companies define IT priorities, we list the most common topics in this area that can be included in the agenda of board meetings:

- Use of new technologies;
- Data security;
- Mobile devices;
- Data confidentiality and information security issues;
- ICT-related capital and operating costs;
- Emerging compliance issues;
- Social media;
- Cloud services and software rental;

Table 1 ESG risk identification questionnaire

Recommendation	*Questions for directors to ask*
Consider how ESG risks could affect your company	What kinds of risks could ESG issues pose to the company? How could these risks interrelate? When could these risks manifest?
Evaluate whether existing processes allow the discovery of ESG risks	What is the company's process to identify risks from ESG factors? Which ESG risk factors is the company already tracking?
Look to a range of sources in identifying ESG risks	What sources were consulted to determine the company's ESG risks? What are our corporate peers doing on ESG risks? What ESG issues do our top investors think are most relevant to our sector?
Be aware of assumptions in the risk identification process	Did management assess ESG risks that the company could face in 1, 5, 10 and 20 years? What blind spots about ESG risks may exist in the risk identification process?
Integrate identified ESG risks into the Enterprise Risk Management (ERM) process	Who owns the ERM process internally? Does the ERM process consider ESG risks? Is the ERM process agile?
Assess the information the board receives on prioritized risks	Does the heat map/risk assessment appropriately reflect ESG risks? Has the company performed a scenario analysis on the most relevant ESG risks and their possible impacts on the company?
Use a materiality lens	Do the prioritized ESG risks materially affect the company? Have we considered stakeholder and shareholder input in making this determination? Have we considered how the ESG risks may interrelate?
Consider the board's skills to evaluate ESG risks	Do we discuss our ESG risks at regular intervals? Is the board regularly briefed on relevant ESG trends and how these trends could pose risks to the company?

(continued)

- Optimization of business processes with the help of digital tools (Cloyd 2013; CPA, n.d.).

Table 1 (continued)

Recommendation	*Questions for directors to ask*
Ensure that prioritized ESG risks are surfaced appropriately in board discussions about corporate strategy, whether at the committee or full-board level	Do we discuss our ESG risks at regular intervals? Are ESG issues addressed systematically? How are ESG issues integrated into our strategic planning and execution?
Consider how prioritized ESG risks affect organizational strategy	What is our risk tolerance for ESG-related factors? Is the company prepared to respond in case ESG risks manifest? Who has responsibility for managing identified and/or prioritized ESG risks? Could the ESG risks we face disrupt our business model? What business opportunities do these ESG risks present?
Understand what strategies are available to mitigate or adapt to ESG risks	Can the company avoid the risk? Does the company have a plan for managing the risk? If the company can neither avoid nor manage the risk, what adaptation measures might lessen the impact?
Hold executives accountable for addressing ESG risks	To what extent are prioritized ESG factors linked with executive goals and performance? How are ESG factors incorporated in executive compensation plan design in the short term and in long-term?
Formalize oversight of ESG risks at the board level	How is the board currently structured to oversee ESG risks? Would explicit reference to ESG in a committee charter enhance our approach? How should the audit committee address ESG risks? When should ESG factors be elevated for consideration by the entire board?
Ensure coordinated deliberations on ESG risks across committees	How could ESG risks fit into deliberations taking place across the board committees? How could these deliberations be better coordinated?
Disclose the board's role in overseeing ESG risks	What should the company disclose about the board's role in ESG risk oversight?

At the same time, the list of priorities can expand and in any case should be determined depending on the needs of the enterprise and its development strategy.

Evolution of the BoD agenda drives changes in the company's organizational structure. Many digitally mature enterprises at the operational level focus on having a Chief Digital Officer (McDonald and Rowssel-Jones 2012) or a Chief Information Officer[2] in their organization, while at the strategic level they opt to set up dedicated BoD committees (e.g. FedEx, United Stationers, Proctor and Gamble, etc.).

In its study, Spencer Stuart highlights that neither a single board member specializing in digital technology nor a chief digital officer are an efficient solution that could substitute for the remaining board members not being digitally savvy enough. The study argues that this approach of the board of directors to addressing digital challenges needs to change given that the board members themselves often fail to fully understand which type of executive possessing which skills and capabilities they are looking for. In reality, many "digital" BoD members may not have the requisite board experience and fail to fit in, which, for one, would prevent them from contributing to the company's business. This leads to the suggestion that in the digital age all board members should be digitally savvy to this or that extent and bear collective responsibility for the end result. This approach implies continuous training of BoD members, engagement of external experts for joint discussions, acquisition of interest in technology start-ups, etc. The same approach favors the establishment of advisory boards, e. g. to cover a broad range of matters related to digitalization. A case in point is the VTB Bank Shareholders Consultative Council that was set up in 2009. Experience shows that the most effective BoD members are those who are broad business thinkers able to influence and educate other BoD members on the impact of technology on the business as well as clearly articulate the ways that technological and digital advancements affect business strategy.

In this context, the role of board committees increases significantly. They are generally set up to look after a subject matter that requires special expertise beyond the scope of its regular activities. As evidenced in practice, as a rule, the audit committee addresses ICT-related issues (CAQ 2018)[3] (less frequently—the risk committee). Given the committee specifics, some issues like cybersecurity fit logically within its agenda. However, taking into account that with digital solutions it is not always possible to assess and mitigate potential risks, such a committee's main focus may prove to be limited when it

[2] The 2016 Chief Digital Officer Study by PWC highlights that 19% of surveyed companies have a chief information officer, with this figure being 38% for companies from Europe, the Middle East and Africa and 23% in North America. For details see PwC (2016).

[3] The Center for Audit Quality (CAQ) has developed this tool to help audit committees execute their oversight responsibilities for financial reporting impacted by emerging technologies.

comes to a broader range of emerging technology-related topics including, inter alia, innovation and company competitiveness. One should recognize that in the digital age risks cannot always be forecasted, which may hinder the use of financial control methods. In addition, the audit committee is also prone to consider technological issues through the financial, operational and control frameworks and views technologies as an operational cost item rather than a tool to create strategic opportunities (McDonald 2013). This may also result in an excessive focus on technological risks (e.g. cyberrisks) and compliance-related issues.

Some companies (Procter & Gamble, Wal-Mart, FedEx, etc.) started creating board-level IT governance committees alongside their audit, remuneration and risk committees in the early 2000s. Composition of such a committee was traditionally a focus. The committee chairperson plays the pivotal role. It makes sense for the committee to be comprised of independent directors similarly to audit and remuneration committees. Understanding of not only the technology solutions that the company currently needs but also a general comprehension of the company's goals and insight into the trends in the industry(-ies) that the company operates in is key for success. It makes sense for such a committee to cooperate with other board committees to shape and implement the company's overall development strategy. In addition, it appears to be in the company's best interest to have at least one member of each committee included in other committees (Nolan and McFarlan 2005).

The Bank of Russia recommends that boards of directors consider whether they need to create an IT committee. If they decide in favor, it is suggested that the committee be chaired by one of the BoD members who has relevant competences and experience. It is further suggested that the committee's scope should include developing recommendations for the BoD in terms of approving IT strategy and policy, overseeing the arrangement of IT management processes, keeping up with and responding to evolving information technology (Bank of Russia 2019).

In the light of increased attention to ESG factors the creation of ESG Committees has become a significant tendency in corporate governance.

As such the determination of whether the set of responsibilities for ESG risks oversight should be added to the agenda of existing committee or incorporated in a more focused newly created committee will depend on factors including the type and magnitude of issues, the terms of reference of the existing committees and the culture of the board. For example, the board of directors of Nike, Inc. formed a Corporate Responsibility and Sustainability Committee which includes in its Charter the following responsibility: "Review and provide guidance to management on sustainability issues and impacts, and the integration of sustainability into Nike's business, including innovation, product design, manufacturing and sourcing, and operations" (Nike, n.d.). According to Bloomberg LP's in 2015 123 S&P 500 companies had assigned responsibility for oversight of ESG/CSR to a board committee up from 116 in the prior year (KPMG 2017).

It would be sensible to reflect the changes in the BoD agenda in the organizational structure of the company and BoD committees. However, in real world scenarios, dedicated committees, assisting the BoD to focus on a specific subject matter are established rather rarely (Bankewitz et al. 2016). According to the U.S. Technology Spencer Stuart Board Index 2019 research, only 8% of 200 surveyed major US technology companies have established a BoD committee on science and technology (Spencer Stuart 2019). It should be noted that establishing a BoD committee is not always the best practice that has to be followed by every company. It all depends on the specific company (industry, level of IT development in the company, etc.), and for some of them it may result in a waste of time and resources (Nolan and McFarlan 2005). Therefore, the issue of establishing a dedicated IT committee needs extensive advance consideration (McDonald and Rowssel-Jones 2012).

4 Conclusions

The ongoing digital transformation gives rise to new and diverse business challenges. A company's BoD and management could delegate or ignore ICT and ESG decision-making in the past, but now in many sectors of economy this behavior would undermine the strategic business development since for many companies ICT and environment protection have turned into a tool for survival and growth. At the same time ICT governance being a part of the corporate governance is becoming more and more important for their functioning, since it helps getting to their strategic objectives, while ESG principles incorporation becomes a necessary tool for investors attraction, corporate image and market value protection. This is reflected both in organizational changes and in the evolving BoD meeting agenda.

BoD members' capability to raise the "right" questions and find systemic solutions is taking an important role in improving the efficiency of ICT governance and ESG principles adherence by the BoD. What needs to be understood is that efficient ICT governance in one entity is not a guarantee of the same result in another. It depends on a multitude of factors to be taken into account when developing and taking on board existing models, structures and standards for governance. Thus, ICT governance and ESG principles application, as one of the most important task for BoD and management today, require them to follow a systemic ICT governance procedure based on specific features of their company and its development strategy.

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The State Food Policy in the Context of Modern Crises

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1 Introduction

The crisis situation in food security at the national level is influenced by negative external economic factors and manifests itself in a number of specific signs:

1. Inefficient organization of the state and municipal regulation of the system of further functioning and modernization of agricultural production and the subsequent unreasonable policy aimed at ensuring the

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optimal volumes of food imports. All of the above cause damage to domestic producers.

2. Lack of the required level of resource security in the food production sectors. Taking into account the specifics of the majority of international economic crises, it is necessary to emphasize the specific issue of financial support to production processes and further economic operations. Thus, the fall in the level of financial stability of the production and consumption system directly affects the fall in the level of output of demanded products in the state.
3. Conditions of the modern socio-economic crisis can violate the basic principles of food security, which consist in the presence of an optimal level of accessibility and sufficiency of various types of food commodities. At the same time, accessibility of food commodities is considered in two aspects: (1) 'physical' provision—stable and seamless food supplies in accordance with public demand; (2) 'economic'—the availability of food products at the optimal price and at the required quantity. The last condition is associated with such indicator as 'sufficiency' of quantitative and qualitative characteristics of food commodities, which are formed due to the state's own capabilities and the optimal volume of imports. In taking a comprehensive approach to the examination of the nature of the modern socio-economic crisis, it is necessary to highlight the politico-economic component determined in the absence of the required level of effectiveness in the state regulation of the crisis situation. This component is reflected in the unreasonable and irrational system of measures of the legislative and executive authorities aimed to determine the achievable share of the main types of food commodities in the total volume of their consumption, based on the use of domestic agricultural and industrial food sources of various types of food.
4. One of the consequences of the international crisis may be a decrease in the level of economic independence of the country alongside with an increase in the role of foreign supplies of goods and production resources. In particular, this causes the presence of a direct threat to food security, which lies in the lack of independent opportunities for seamless supplies with a potential risk of influence from another state or an international economic organization.
5. The crisis situation determines a significant limitation of the possibilities to form and maintain the required quality of strategic food stocks. On a general basis, this happens by assessing and determining the optimal priorities for obtaining food commodities. In this case, such factors should be taken into consideration: (1) ability to ensure the storage and accumulation of food commodities; (2) determination of the procedure for using existing stocks; (3) availability of effective means of transporting these stocks in accordance with the specifics of the sales of food commodities on the domestic market.

The evaluation of these factors of the international economic crisis should be closely related to the identification of the probability of the negative impact of a number of potential threats that can manifest themselves in the process of providing food security. These threats are:

1. Relative equilibrium in the food market can be achieved by narrowing the effective demand of the population against the background of the number of serious problems in agricultural production.
2. Under the influence of the emerged crisis, the level of basic food consumption is far below than the established consumption standards, both, in terms of the total energy value and in terms of the structure of the regional distribution of food in the state.
3. The previously noted process of irrational government regulation of the food commodities supply from foreign manufacturers causes a significant decrease in the level of competitiveness of domestic manufacturers. In turn, this significantly reduces the activity of implementing entrepreneurial initiatives of small and medium-sized enterprises, which largely prevail in the agro-industrial complex.

It is necessary to note the impact of production crises, which are largely depend on the level of stability of financial support for the industrial and economic processes. These crises can manifest themselves in the following forms:

1. Decline in the share of production in the structure of agriculture and fisheries, as well as in the food industry under the influence of financial factors and insufficient level of resource provision of existing production capacities.
2. Inefficient technological and property modernization of production systems. Lack of promising innovative means aimed at improving qualitative and quantitative characteristics of manufactured food commodities.

The last of these forms, in turn, is associated with several special negative phenomena in the production and subsequent problems with food consumption, namely:

1. Expansion of the range of different costs arising in the process of manufacturing food commodities, as well as their excessively high level.
2. Narrowing of the output products assortment.
3. Decline in the level of marketing opportunities offered on the food market in the absence of rational advertising technologies.
4. The crisis in production can cause a decrease in the quality of produced food commodities, which, in particular, may be associated with the loss

of qualified personnel in production and the lack of qualitative raw materials.

In this case, the consequences of the production crisis are manifested themselves in the field of trade and industry, specialized in the processing of agricultural raw materials to obtain ready-to-eat products. These spheres of economic activity and production also have a number of negative signs with an insufficient level of modernization of existing technical means and technologies, namely:

1. Inefficient organization of storage of inputs and raw materials.
2. Outdated processing methods and lack of diversity in production technologies.
3. Untimely and sub-optimal use of innovative tools in production. Low level of personnel management in enterprises based on various forms of ownership.

2 Materials and Method

Theoretical and applied research on the assessing the effectiveness of public administration of the agro-industrial complex are considered in the works of many domestic and foreign authors, such as Gorlov et al. (2018a. b2020), Plotnokov et al. (2020), Fedotova et al. (2020), Glushcenko et al. (2020), Sergeev (2018), Sergeev et al. (2017), Gorlov (2017a; b), Omarov et al. (2017), Shagajda and Uzun (2015), Krylatyh (2012), Konkin (1999), Hramcov and Onoprijko (1998).

Nevertheless, despite the abundance of publications on related topics, the issues of providing the population with affordable meat products and the growth of meat production in modern conditions are poorly studied. In the aspect of elaboration of a direction of the meat industry in Russia, it is necessary to review and to complement the existing instruments of state management of the agro-industrial complex in order to increase the efficiency and safety of food security building activities. The research is carried out using the methods of graphical presentation of information, statistical analysis, trend analysis, the methods of comparison, analogy and systematization.

3 Results

The crisis situation in international agricultural processes and in the agro-industrial complex of an individual state manifests itself in a decrease in the quality of processing of available resources and application of manufacturing technologies, which is expressed in the following:

1. Irrational use of biological, material, scientific and technological capacity.

2. Violation of the system of distribution of available resources between agricultural producers due to the crisis in the implementation of business initiatives of small and medium-sized enterprises.
3. Low level of development and restoration of structural elements of infrastructure and transportation system of enterprises and organizations involved in the process of the development of the food sphere of public life.

The imbalance in relationships between producers and consumers among the regional markets of individual states determines a decrease in the productivity of the main sources of the raw materials for food production.

The inefficient international anti-crisis economic policy in financial, material and technical support and in maintaining a high level of human capital activity increased threats to the ensuring the basic needs of the population. First of all these threats consist in the lack of stability in maintaining food security in society and in the possible violation of the state's food sovereignty in the system of international economic relations.

The key goal of this food security is the formation of the necessary production factors and the manufacturing of demanded in the society assortment of food commodities. Each component of this assortment must fully comply with the established norms of quantity and quality, which ensures full satisfaction of the public needs, and, as consequence, serves as the basis for obtaining a high income made from sails on the food market.

The negative impact of the socio-economic crisis is expressed in the violation of the quality of produced and sold food commodities, as well as, in the narrowing of the optimal range of these goods.

Often, a number of varieties of such goods become inaccessible to most consumers at the level of the whole society or in the individual territories. This lack is evident in the following:

1. Existence of a shortage of qualitative goods due to the insufficient level of their output (which is typical in a production crisis).
2. Due to the low standard of living and insufficiently high wages of the working population, many types of food commodities are inaccessible to the consumers.

One of the examples of these crisis situations is the food crisis of 2004, which largely resulted in the decrease in the level of food security. This manifested itself in rising food prices, a decline in the quality of a number of food varieties and a fall in consumption. The significant decrease in the level of production activity of a number of manufacturers, including in the structure of the agro-industrial complex, should be taken into considering. In turn, this caused a decrease in the level of competition in the food market and the growth of monopolies, which reflected in a decrease in the activity of small and medium-sized enterprises in food industry. The increased danger of modern economic crises lies in the presence of unpredictable factors and phenomena that can have a negative impact on the food security of society on a national or individual scale.

The financial nature of modern international crises determines such a market phenomena as volatility in the structure of the supply of various types of food. Thus, the high dynamics of price volatility for these goods directly determines the destabilization of the situation in the food market. This is especially true in a situation of coincidence and combination of elements of the agro-industrial and general economic crises. In the determined situation of price volatility, the particular importance have the speculative transactions in the food and food-related goods market.

It should be noted that decrease in the level of competition appear with the expansion of monopoly in these markets and the predominance of large companies as intermediaries between agricultural producers and consumers.

In the context of the international financial crisis, a number of special factors that determine the negative impact on the food security of an individual country should be identified, namely:

1. Lack of necessary funds to solve the problems of producers and consumers relations in the field of market sales of food. In particular, this is reflected in the fact that in certain territories manufacturers, which need additional financial investments, have to adapt to a climate change.
2. Decrease in the volume of purchases and consumption of food in the structure of international transactions due to a sharp fall in exchange rates.
3. Aggravation of the problem of monetary relations, which is characterized by increasing interest rates, which significantly complicates the fulfillment of credit obligations of agricultural producers.
4. Restriction of the activity of banking organizations while withdrawing their deposits in other credit institutions, which reduces the scale of lending in food production.
5. Violation of the stability of settlements between companies in the food market by means of financial instruments.
6. The crisis of monetary circulation and financial support for resource provision for the modernization of agricultural technologies used in land cultivation and the production of quality products.
7. Increase in the level of debt obligations of private business entities in the structure of food production in the absence of opportunities to reimburse their main part.

In assessing the negative nature of the influence of the price factor, we should highlight the existence of an imperfect pricing mechanism, which causes a violation of the price balance for raw materials, efficient means of production and finished products in the food sector.

The disruption of the optimal scale of product imports leads to saturation of the domestic market with foreign goods, which causes significant damage to the development of domestic entrepreneurship. In the context of an international industrial crisis, this is fraught with catastrophic damage to domestic consumption in the absence of productive domestic sources of food commodities.

Rising food prices can significantly exceed the growth of total consumer income, as well as significantly reduce the ability to pay for most transactions in the food market.

Considering the specifics of the development of agriculture on a global scale, it is important to note the uneven dynamics of production processes. This is the basis for the fact that in most third world countries, an example of which is a number of African countries (for example, Ethiopia, Angola, Democratic Republic of the Congo), a low level of food production is observed. This situation is caused by the orientation towards the cultivation of export industrial crops rather than food commodities for their own needs. Thus, an almost continuous crisis state can be noted. This state determines:

1. Low level of material and technical base.
2. Direct dependence on the conditions of the natural environment and the lack of modern means of chemical protection of crops.
3. Insufficient supply of raw materials to other areas of agricultural production.

In the context of the international economic crisis, these negative phenomena are even more aggravated due to the dependence on foreign aid and imports of additional agricultural products.

The instability of prices in the world food market is largely caused by an increase in demand from countries in which the population is rapidly increasing and industrial production is developing (for example, China, India). When the mutual dependence of various countries is expanding, negative phenomena in certain regions cause deviations in economic processes in other regions and states.

This phenomenon determines the onset of both positive and negative consequences in the structure of the growth of economic interactions, and therefore, the formation of conditions for a decrease or increase in crisis signs in the food security of individual countries. For example, a change in the level of competition in the system of production and trade of food stimulates the expansion or contraction of entrepreneurial initiatives of the member states of the world community.

Due to the predominance of monopoly companies in the absence of an effective international policy of limiting trade monopoly, national producers' presence on the food market is decreasing.

The global financial and economic crisis determines a significant reduction of the market for exports from developing countries. That is associated with a decrease in the inflow of foreign investment, as well as the amount of humanitarian aid in the context of an acute food crisis.

The unstable situation in the global economy turning into a crisis causes the increase in financial assets, which are associated with increased risks of further monetary losses. Different investors significantly reduce or completely abandon investments in economic processes in food sector.

The most obvious consequence of the decrease in the inflow of financial investments and capital is the fact that most banking organizations face the problem of a significant reduction of the value of their assets. That causes a reduction in the size of cross-border loans and is complemented by the violation or termination of economic and business relationships based on trust between certain companies.

Further, this causes a set of negative conditions in which the level of financial support and lending to individual economic entities, in particular, food industrial enterprises and companies specialized in the primary and subsequent processing of agricultural products, is reduced.

Thus, in close relationship with the insufficient level of foreign direct investment (FDI), a limiting, and in some cases, catastrophic impact on the production and trade of food takes place.

At the same time, the ongoing international economic and financial crisis determines the reduction of these investments in two key areas:

1. The volume of international loans is significantly reducing. This reduction is associated with the establishment of higher interest rates on loans and requests for pledge of property. A particular manifestation of this decrease in loaning is a reduction in financial support for agricultural producers, which reduces the level of their economic activity.
2. Decrease in the flow of investments in the food industry. In turn, the sequence of lending to the farms and other suppliers and producers of food is significantly disrupted.
3. The crisis of the banking and monetary system on the scale of a number of countries.

4 Conclusion

At the end of the study, it is important to note that the negative consequences of international crises are closely interconnected with each other in the general system of international flows of manufactured products and financial capital. At the same time, it is necessary to note the negative factors related to insufficient development of production and problems of further improvement of manufacturing technologies, as well as the subsequent sale of this type of product on the market. Taking into account the predominant importance of financial aspects in modern crisis situations, it is necessary to note a number of obstacles on the way to food security resulting from instability of exchange rates and a decrease in a level of lending to private business entities functioning in the field of creating primary agricultural raw materials and further manufacturing of food commodities.

There are a number of special indicators, which should be taken into considering in assessing the impact of the international crisis on food security:

1. Stock levels of produced and accumulated food, which can be used to receive the optimal production results in the short term (for example, obtaining the required amount of grain crops, what is practiced in the states—the main suppliers of agricultural products).
2. Level of world grain reserves and the level of world food production on average per capita.

These two key indicators of food security of the world community are closely related to a number of indicators of this security at the level of individual countries:

1. Competitive relationship between the domestic food production and imports.
2. Size of strategic and operational food stocks in the short and long term.
3. Level of demand and consumption of the most important products.
4. Degree of price stability for the main varieties of food.

A system of conditions to maintain the availability of food commodities to the population is formed at the optimal level of these indicators.

It is particularly necessary to highlight the insufficient level of informational support for production processes aimed to stimulate the output of the necessary varieties of food. In modern socio-economic conditions, an insufficient thorough analysis of the international economic situation and the lack of information about the economic behavior of foreign companies can lead to an aggravation of the food situation in the Russian Federation.

Thus, the food component of the social welfare in an individual state is under the influence of the international economic crisis and is affected by negative impact of many economic and financial factors. The complicated nature of the modern international crisis has a complex negative impact on food production in an individual country, which is reflected in a decrease in the level of this production, its resource provision and instability of the financial conditions of production processes. These negative phenomena can be effectively limited or completely eliminated on the basis of constructive interaction between government structures of different countries and representatives of private entrepreneurships operating in the global economic space.

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Corporate Fighting Climate Change in the Economy of the Future Based on Capabilities of Industry 4.0

Development of Environmental Responsibility and Related Practices Among Russian SMEs (Based on a Survey)

Liudmila M. Cheglakova, Bela S. Bataeva, and Olga A. Melitonyan

1 Introduction

Improvement of environmental responsibility is an important challenge that Russian Federation has to address at present. The country's orientation on commodity exports through 1990s and early 2000s resulted in anti-sustainable trends: an increasing share of the polluting and nature-exploiting plants in the national economy; export patterns based on natural resources, high rates of damage to the environment caused by pollution, environmentally unbalanced investment policies etc. (Bobylev 2017, pp. 91–92). Currently Russia faces the task of creating its own national Strategy for Sustainable Development in the context of implementing United Nations Sustainable Development Goals within "The 2030 Agenda for Sustainable Development" (General Assembly 2015), this marks a transition to the new type of economy. Industry 4.0 shapes

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the demand for environmentally responsible behavior of both large, medium and small firms, dissemination of "green" technologies.

In Russia, small and medium enterprises (SMEs) create only 20.0.2% of GDP, however, those companies employ over 19 million economically active individuals (RBC 2020). As stipulated by the National Project "Small and Medium Enterprises" (Passport of the National Project 2018), the share of SMEs in the Russian economy should increase to 32.5% by 2014, and their share of employment should reach 25 million people. Globally, SMEs account for more than 90% of the total number of firms and are responsible for more than 70% of pollution (Nikolaou et al. 2016). Therefore, the formation of environmental responsibility among small and medium enterprises is of utmost importance in order to prevent further negative consequences for the environment and preserve nature. In the Russian Federation, this task corresponds to the performance of the instructions of the President dated 2017 (List of Activities 2017), reflected in the strategic documents aimed at providing environmentally sustainable development of the country.

Corporate social responsibility (CSR) constitutes a tool for achieving sustainable development within an organization or a company. It includes various business areas. According to the ISO 26000 standard, social responsibility means organization's liability for the impact of its decisions and activities on society and the environment through transparent and ethical behavior. Thus, environmental responsibility is considered as an integral part of the company's social responsibility. In legal terms, this is "the obligation to bear responsibility in the form of adverse consequences for the committed environmental offense in accordance with the sanction of the violated legal norm" (ISO 26000:2010 2012). This paper examines the environmental aspect of SMEs' social responsibility reflected in their environmental/sustainable practices, therefore, making it possible to observe SMEs' environmentally responsible behavior.

The purpose of this work is to observe an environmental component among the areas of SMEs' social responsibility.

The objectives of the study are:

- to identify the presence of environmental practices in the activity of Russian SMEs;
- to identify the main drivers for socially responsible behavior and implementation of environmental programs by SMEs;
- to propose measures for developing environmentally responsible thinking among Russian entrepreneurs and environment-related practices of responsible behavior among Russian SMEs.

At present, there is an expert commentary that in Russia environmental problems in the context of corporate social responsibility are in a subordinate position compared to the solution of social problems (Belikov 2019). In developed countries such as Germany, Japan and the countries of Western Europe, CSR presumes, first of all, solving environmental problems, saving resources, and assisting in combating climate change. There are concerns that amidst economic malaise, spread of the coronavirus and shortage of funds, investing in environmental and resource-preservation measures will be further hindered. Regional and local authorities, due to the scarcity of local budgets, often opt for preserving jobs even if those are at plants that use outdated equipment with damaging environmental trace, technologically hazardous production sites are created without complying with measures of environmental protection in an attempt to increase tax revenues and minimize necessary investments into maintaining environmental safety. The problem is aggravated by the weak activity of environmental NCOs.

The literature on management contains various examples of SMEs' successful practices and innovation abilities on the introduction of environment-protection instruments in developed countries. The size of their enterprises, according to (Moore and Manring 2009), provides SMEs with a competitive advantage when forming their social and environmental responsibility compared to MNCs. Smaller firms are more flexible and creative, they learn and change faster, adopt innovations that have emerged overseas. The focus on sustainability enables SMEs to achieve rapid growth. Further, innovations that have emerged in SMEs are adopted by MNCs through merging with small and medium-sized enterprises.

Testa et al. (2017) are considering how pressure on businesses from the perspective of environmental responsibility leads to the development of environmental practices. The impact of products on the environment and services is calculated exemplified by a cluster in Italy and the Cardato Recycled program in the fashion industry and based on the life cycle assessment (LCA): from the extraction of raw materials to the final product's, process' or service' end of life. (Cote et al. 2008) analyze environmentally responsible SMEs in Nova Scotia, Canada and the benefits of the collaboration across several SMEs within the same territory during the supply chain implementation.

A series of contributions outlines the drivers for environmental responsibility and green innovations in case of SMEs in emerging markets, which include Russia. (Guo and Shi 2012) consider the impact of an external environment (policies and laws, culture, finance, science and technology, market, services, etc.) on the growth of innovative SMEs in China. (Seth et al. 2018), by the example of Indian SMEs, look into the drivers of green manufacturing. Based on interviews with experts, the authors of this paper identified 13 drivers of SMEs' environmental innovation: environmental regulation and strict enforcement, supported by legislation; fines for non-compliance with norms and standards; financial incentives; leadership/top management commitment; modernized and innovative control measures, etc. (Seth et al. 2018, p. 1391). Moreover, the authors compare the incentives for the green manufacturing development in SMEs in contrast to larger businesses. The authors emphasize that the identified drivers (incentives) should be applied with respect to the social and cultural, political and economic environment of the country. The effectiveness of any decision can be understood only in the context of social and political, legal, demographic and economic conditions which these decisions are made under.

Contrary to a widespread scholars' belief that companies in developed countries are increasingly feeling the economic feasibility for environmental sustainability and are restructuring it in response to signals from the market, a number of empirical studies of SMEs points to the fact that their owners and managers' opinions marginally resonate with this "win–win" rhetoric. Research by (Revell 2007) showed that entrepreneurs in the construction sector did not feel that profit had been obtained due to eco-efficiency measures and that environmental responsibility is significant and sufficient to compensate for the investments in the time and implementation resources necessary to resolve environmental issues. The same conclusions were reached by (Klovienė and Speziale 2015), who highlighted the need for large investments of time, money and management efforts as the reason for SMEs' low motivation in the development of environmental responsibility.

Nikolaou et al. (2016) showed that managers/owners of SMEs have limited amount of information regarding the influence of their environmental footprint, they also believe that the small size of their operations is not able to cause serious ecosystem externality and impact on natural resources. All this leads to an underestimation of the need for environmental responsibility and low participation of SMEs in environmental activities.

The number of Russian publications on environmental practices and the environmental aspect of the SMEs' social responsibility is next to none. Most of the publications are dedicated to the social responsibility of SMEs in general or the environmental responsibility of business in general, without focusing on SMEs. A group of publications is dedicated to the stakeholders' impact on the environmental responsibility of business in general, but again without reference to SMEs. There is also a small number of works addressing the issues of environmental control within SMEs, if their activities are related to environmental impact.

Savicheva (2010) remarks the low level of social responsibility of Russian small businesses with regard to environmental safety. According to her research, before 2010 "only 15% of small and medium-sized businesses have included environmental programs in their statutes" (Savicheva 2010, p. 35). Whereas in Germany 85% of SMEs give consideration to environmental aspects in their activities (Boboshko and Gusev 2006, p. 33). In their opinion, the low level of SMEs' environmental responsibility in Russia in those years had two reasons: (1) low profit margins of this business segment due to systemic problems of the state economic policy regarding small business; (2) the social irresponsibility of many small enterprises is the result of the state social irresponsibility. The last decade governmental authorities initiated profound changes in this regard.

Yashalova (2017) considers the prospects and the role of SMEs in the development of a "green" economy. According to her opinion, SMEs can become vehicles for creating ecological or "green" business in the country (Yashalova 2017, p. 43). The author mentions as examples some environmentally responsible business models of Russian enterprises engaged in such areas as growing organic agricultural products; production of fuel pellets and biofertilizers; utilization and processing of solid household waste.

Analyzing the environmental responsibility of Russian business, (Wittenberg 2010) remarks the historical reasons that contributed to the wasteful attitude towards natural resources. The reasons, according to the author, are also explained by the lack of state regulation, when "it is more profitable to pay a paltry fine to the supervisory authorities for environmental non-compliance (and more often to bribe an official) than to build expensive treatment facilities" (Wittenberg 2010, p. 34). The author concludes that Russian business generally combines the features of both environmentally responsible and environmentally irresponsible behavior.

In researches on the environmental responsibility of SMEs in different countries, the state is positioned as an important driver of environmental responsibility by means of legal requirements. Although its influence on the formation of environmental responsibility in the literature is assessed ambiguously. Besides (Murphy 2001), argues that if market forces do not provide sufficient incentive to encourage environmental modernization, a clear justification occurs for increased governmental intervention and imperative for environmental reform and capacity building in firms in order to respond to this imperative. But even though a stricter regulatory regime would have a beneficial effect on corporate environmental control and financial management (Porter and Van der Linde 1995), it could create significant bureaucratic barriers for SMEs, especially in trade and foodservice businesses, which in the long run could drive them out of the market (Gerbens-Leenes et al. 2003).

2 Methodology

An empirical study of Russian SMEs was conducted in 2015 and 2017 in 77 small and medium enterprises.

Hypothesis 1 For Russian businesses, environmental issues are less important and their responsible behavior is embodied through other priorities, including social care for customers, employees, charity, etc.

Hypothesis 2 SMEs' responsible behavior is determined by the preferences/personal attitudes of the SMEs' owners and managers rather than by the influence of an external environment.

Hypothesis 3 State regulation by means of environmental legislation, including industry standards, is an important driver of SMEs' green focus in industries were market failures are common.

Personal focused interview was used as a data collection method. The choice of interviews as a method for gathering information was determined by the intention to obtain first-hand information and take the Russian entrepreneurs' opinion towards social responsibility, including its environmental component, as well as to highlight practices of its implementation and the reasons why entrepreneurs chose them. The interview guide included such topics as definition of terms and motivation for responsible behavior; regulation of ethical behavior in the company, including its structural and process documentation, as well as respondents' awareness of the governmental regulation with regard to socially responsible behavior.

77 interviews (59 interviews from 2015 and 18 interviews from 2017) were collected based on a random sample. The sectoral composition of the economy in the sample is well represented. It includes enterprises in the following business areas: domestic trade (18%), professional services (10%), trade and mass catering (10%), finance, credit, insurance, pension fund scheme (10%), manufacturing (6%), transportation (6%), public education, culture and art (5%), construction (5%), information technology and media (3%). Such industries as geology and exploration of mineral resources, geodetic and hydrometeorological services, health care, physical culture and social security, publishing and printing, real estate transactions, communications, non-governmental associations are represented by 1% of companies analyzed (1 firm). Other entities from the production sector comprised 9% of the sample. 8% of SMEs refused to provide information about their industry and the region of operation. The vast majority of companies under analysis operate in the Central Federal Count of the Russian Federation (86%).

The enrolment of respondents was done by means of the snowball method due to the difficulty of accessing companies - through personal contacts and networks of the authors, including other researchers, academic scholars and university graduates who agreed to participate in the study. During the data collection authors monitored such characteristics as the industry, the number of employees in the enterprise and the operation area. The number of respondents included business owners and leaders, as well as employees with a managerial status and at least 2 subordinates.

All interviews were transcribed and encoded. The content-analysis was used for analyzing data from the interviews. According to (Denzin and Lincoln 2008), a four-stage process was implemented in the research: (1) data collection; (2) descriptive analysis; (3) selection of categories; (4) evaluation and data interpretation.

A unit of count is a mention of environment-related responsible practices or activities, initiatives and arrangements held by an SME following one of seven directions of social responsibility "Environmental issues" according to the (ISO 26000:2010 2012). SMEs' motivation of choosing environment-related responsible practices is also analyzed. Main results of the SMEs' survey from 2015 and 2017 are presented further and illustrate their overall attitude towards the aspects of environmental responsibility.

3 Results

Summary data on the number of social and environmental practices named by interviewed representatives of 77 SMEs is presented in Table 1.

According to the results of processing interviews with SMEs' representatives, environmental care is reckoned among the motives of socially responsible behavior (36% of mentions from the total number of respondents), but its priority is lower than the care for employees and customers. A number of respondents perceive a responsible company as the one that is involved in environmental activities:

> A socially responsible company is a company that primarily bears social responsibility to its employees and customers. And it does not forget about important issues associated with the society, ecology - finds opportunities (time, money) to participate in social programs and activities. (Manager)

Most respondents mentioned social care (payments for health insurance, training of employees), birth allowance for mothers or financial assistance in case of difficult straits (63% of references from the total number of responses) when they were asked about their understanding of responsible behavior. Relationship with consumers as a priority of responsible behavior occupies the second place in the respondents' answers (61% of mentions from the total number of responses) and is achieved through the compliance with a product

Table 1 Practices of Responsible Behavior of SMEs according to ISO 26000:2010 (based on the survey results from 2015 and 2017)

Companies' practices of responsible behavior	*2015*	*2017*	*Total*
Responsible management practices	6	11	17
Human rights	3	7	10
Labor relation	34	15	49
Environmental issues	*22*	*6*	*28*
Compliance practices	14	12	24
Consumer relations	37	10	47
Participation in the life and development of local communities	9	12	21

or service quality standards, attention to customers, provision of fair information about the products' features or their quality, reaction on the feedback from customers and settlement of complaints.

Specifically, medium-sized enterprises predominate among the companies that pointed out environmental responsibility: 20 medium-sized enterprises out of 77 cases (26% of the sample) and only 3 small enterprises (4% of the entire sample) designated environmental responsibility as a priority.

Most notably, environmental responsibility was mentioned by representatives of domestic trade enterprises, construction companies, transportation and logistics companies, IT-companies, travel agencies, a publishing and printing company, fitness centers and, of course, specialized environmental organizations.

Representatives of transportation and logistics companies consider minimizing harm from their primary activity as the main driver of environmental responsibility and emphasize its voluntary nature:

> Several times a year, the organization transfers a significant amount of money to the National Environmental Foundation, and also supports the Russian "Green" environmental movement. Why did we choose particularly environmental sector? Our choice is related to the fact that the company is engaged in logistics, that is, cargo transportation of various types. And even regardless the fact that we use environmentally friendly fuel, the environment is partially polluted because of our activities. Therefore, by sponsoring organizations that are focused on defending the environment, we pay a kind of compensation for possible damage to the environment that we could have produced, and thus present ourselves as a company with a high level of CSR. (CEO)

Representatives of the production and manufacturing sectors consider implications of business activities and the well-being of future generations as the main driver of their environmentally responsible behavior:

> At present, many other issues are emerging, for instance, environmental problems, social aspects, and so on. The question is that all these issues must be taken into account, because they may catch up with us not now, but in ten - fifteen years, if we are not able to keep all this within certain limits, then it will cause a catastrophe. (CEO)
>
> No, we do not damage the environment, because our forest yield is much higher than the number of trees we cut. If a tree is left on the stump, it will rot, and this will be a problem, so we need to do it on time. (CEO)
>
> …As to the environment, we can see examples of different countries: the more developed the country is, the higher is their concern about environmental issues. When a businessman cares about anything other than profit-making, it means that there is some sublime philosophy in the society…. (Manager)

Respondents representing medium-sized businesses from the construction industry noted that their firms take an active part in investing in the environmental sector, namely in the construction of treatment facilities, haul roads, and regulate the processing of hazardous waste in the Moscow region.

Responses analyzed evidence that by contrast with social initiatives (assistance to pensioners, children, shelters), where many incentives originate from the employees (Bataeva et al. 2020), the choice of the environmental responsibility is largely determined by the SMEs' owners preferences:

> We support the environment, but we do not invest in other people's electric vehicles, we just reduce commissions. Why particularly these areas, and not some others? Just because I like it and my partner approves of it too. (CEO)

Or another respondent's answer: "It is undoubtedly driven by the need. We take on more environmental commitments than are required by law. This is, first of all, the shareholders' position" (Manager).

Describing environment-oriented projects and activities, authors note that they include direct actions such as one-time projects and programs and participation in partner environmental programs.

In this context, it is necessary to mention the emission control of the hazardous waste and the equipment available for minimizing harm to the environment, which are referred to by managers of manufacturing and construction plants:

> …The company uses advanced equipment to reduce emissions and avoid any damage that the chemical industry can cause to nature. (Manager)

Caring for the environment is also demonstrated by direct actions:

> …We do not throw storage batteries into regular waste baskets. We put them into a separate box and then into special containers … we bring them to a battery-processing plant that we build for recycling and processing used storage batteries from our production equipment. (CEO)
>
> There are also a variety of entertaining and educational activities that are held for children and employees: Earth Day and Water Day, when we clean up the territory. Not far from our office there is a forest park zone, we clean it up there and tell the residents of neighboring houses about the need to take care of the environment and save water. Also, currently a program called "Save water" takes place, when we, through various training events, as well as in the media, explain that water must be saved and that it must be clean. (CEO)

As examples of their participation in partner projects, respondents mentioned taking part in environmental programs, such as "Rivers run into the seas", transferring money to National Environmental Foundations, participation in the "Green" environmental movements, participation in a program on leopards' protection. Some respondents indicated that they "clean up territories" and "take out the rubbish in the parks".

Another driver of environmentally responsible behavior is meeting requirements of supervisory authorities, which is considered obligatory but is not always perceived as unambiguously positive:

> We do not produce anything; thus, we do not invest much in the environment, but we have such a type of activity as cargo transportation, which implies an environmental tax. (CEO)
>
> For instance, there are penalties for violating environmental legislation. If the Vodokanal laboratory finds that harmful substances in the sewage runoffs exceed maximum permissible concentrations, then for each parameter you receive a penalty of 20 thousand rubles! So, once you washed clothes used by production workers with powder at work, and at this time Vodokanal specialists took samples in the well, the result is "get a penalty"! (CEO)

As illustrations of environmentally responsible behavior in their industries respondents referred to Western companies or well-known brand stories about the companies' investments in recycling, energy saving or water purification. For instance, a manager of a travel agency cites the case of the "Lush" company for human skin care, which does not use animal tests and uses recycled plastic for its cream tubes.

Overall, the respondents value the quality of environmental legislation and the practice of its enforcement at a low rate, primarily due to the dismissive behavior of major companies:

> Probably, if we talk about the governmental requirements, then we can approach environmental standards for mining companies, which still no one complies, but pays penalties…. (Manager)

Whereas, some respondents explain their unwillingness to develop environmental responsibility by the fact that green focus exclusively refers to major companies' performance:

> I think that almost all companies of the top fifty, large, public, somehow include business ethics in their activities, because for them it is the must … If we take Toyota, it is proud, that they are constantly sweating over making their steel engines more and more environmentally friendly … Toyota significantly exceeds the emission requirements that are prescribed for them, but they make their cars much more environmentally friendly than required, so almost all major companies, anyway, say that they bear explicit social responsibility. (CEO)

An important feature of the Russian SMEs' practice, as it appears from the results of this study, and what many respondents indicated, is that the reason for socially and environmentally responsible business behavior is the shareholders' and senior executives' personal choice:

> … I believe that business ethics exists in Russia thanks in large part to the initiatives of private entrepreneurs and business leaders. So, major or state-owned companies, in my opinion, should dedicate more time to this, because currently small and medium-sized businesses are pushing forward social programs much more actively. (Manager)

4 Conclusions and Recommendations

The results of this research confirmed hypothesis 1, which states that for Russian business the priorities of responsible behavior include environmental practices (36% of the total number of companies surveyed), but they take a lower position compared to practices related to labor and consumer relations (63% and 61% references respectively). Overall, the depicted tendency coincides with the conclusions (Belikov 2019) on the priority of social activities over the environmental agenda.

Hypothesis 2 was also confirmed for the fact that the external environment, broadly defined as a set of social, cultural, political, economic conditions and public opinions expressed by politicians and customers, is not a CSR driver in case of SMEs. Russian business does not receive clear signals from the market for incurring environmental responsibility. The link of responsible behavior with the company's reputation and brand awareness was noted by few respondents. The owners' and managers' views resonate little with the 'win–win' rhetoric specified by the government and industry programs, politicians and community leaders. This is consistent to conclusions of (Revell 2007) and (Savicheva 2010). Therefore, the environment has not yet become a significant driver of the SMEs' environmental responsibility.

As to the role of SMEs' owners and managers in defining priorities of responsible behavior, many respondents from companies that work in the B2C market segment indicated that practices are, indeed, chosen based on "the owner's personal attitude and preference".

SMEs' environmental initiatives mostly are non-systematic one-time activities, including the ones organized as participation in well-known environmental programs and events of local communities.

Environmental responsibility is more often mentioned by respondents from companies that cause damage to the environment directly or indirectly by their operations: transportation companies, businesses from the production and manufacturing industries. Many firms in the Central Federal Count invest their resources in the construction of treatment facilities, haul roads and hazardous waste recycling of their own will. Companies from the industry of domestic trade, logistics, IT, catering and others that work primarily in the B2C market segment are joining the voluntary initiatives. This behavior is typical for the medium-sized enterprises rather than for the small ones.

Many respondents believe that environmental responsibility is rather an attribute of major, public companies' operation and activity, and are not fully aware of the SMEs' contribution to environmental pollution, as previously stated by (Nikolaou et al. 2016).

A weighty conclusion is that almost none of the respondents indicated that environmental responsibility contributes to their competitive advantages, including activities within joint projects with other SMEs. An insignificant number of respondents mentioned participation in joint environmental programs with other partners.

This provision allows for the enhanced governmental regulation, which according to (Murphy 2001) compensates for weak market incentives and justifies increased governmental intervention, its establishment of environmental reform agenda and encouraging firms to respond to these imperative demands.

Hypothesis 3 stating that governmental regulation through environmental legislation and industry norms is an important driver of SMEs' green focus in industries characterized by market failures, has been confirmed. The state, by means of legal requirements, is an important driver of environmental responsibility in production and manufacturing companies.

It should be noted that resource pooling, joint actions with partners are still poorly used by Russian SMEs from the sample. This form of cooperation is successfully used by SMEs in European countries as a response to economic trends related to globalization and the requirements of environmental legislation during economic crises (Nikolaou et al. 2016). Strategic alliances and collaborations with partners, industry peers, universities and financial institutions help individual small and medium-sized enterprises manage their environmental risks.

As the result of the research, the following recommendations on developing SMEs' environmental responsibility are formulated:

- environmental education and training for entrepreneurs and managers, shall be strengthened. Among other things, this will contribute to formation of responsible SMEs' leaders who are aware of effects their companies produce towards the environment and are able to pioneer innovations in the field of environmentally responsible behavior;
- environmental responsibility shall be promoted among the population, and specifically among entrepreneurs, relevant training programs shall be developed and offered;
- tax policy shall be adjusted (additional taxation of resource consuming and polluting plants shall be introduced, as well as, probably, tax support for environmentally responsible enterprises).

- the creation of non-profit organizations (unions, associations etc.), including those of SMEs and universities, professional and industrial associations, within which it may be possible to borrow and disseminate green innovations, shall be encouraged;
- professional and industrial associations shall be involved in formulation of an agenda for SMEs' environmental responsibility.

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Environmental Responsibility of Fashion Industry Multinational Corporations (MNCs) in the Context of Industry 4.0

Igor B. Dolzhenko and Anna A. Churakova

1 Introduction

Globalization has significantly affected the fashion industry through production, distribution, logistics, marketing, and sales. Consumers' fashion perception has transformed, as well as their needs. Information and communication technologies have radically changed the speed and methods of transmitting information about each new fashion industry trend.

Fashion is a complex global industry with a turnover of $1.9 trillion in 2019, and sales of clothing and footwear are expected to increase to $3 trillion in 2030. (O'Connell 2020). The fashion industry shows positive growth, especially in emerging markets of Asia–Pacific and European regions. Per capita, consumers in the Netherlands buy the most clothing items per year, followed by consumers in the United States. In 2019, US consumers spent around $370 billion on clothing and footwear, including around $110 billion on e-Commerce clothing purchases and $260 billion from retail channels (O'Connell 2020).

The global fashion industry is a significant employer—there are about 40 million jobs worldwide (excluding retail trade channels that generate 3–4 times more jobs). Over the last 20 years, the number of clothing production jobs in Western countries has sharply dropped. In the United States, the number

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of people employed in clothing production has decreased from around 900 thousand people in 1990 to 110 thousand people in 2019 (O'Connell 2020). In the UK, 555,000 people work in the fashion industry; more than 75% of fashion jobs are in the retail sector (UK Fashion Industry Statistics 2020).

Globalization has affected all the elements of fashion companies functioning. Suppliers and clients of fashion companies participate in global value chains (GVCs), which are usually managed by large international companies—multinational corporations (MNCs) (Konina 2018). As part of global value chains, most production capacities moved to Asian developing countries, where the cost of labor was comparatively low; however, management companies focused on fashion brand management remained based in Western countries to more efficiently promote products. Developing countries provide a lower level of environmental monitoring; there are fewer environmental restrictions and regulatory agencies.

Current trends in fast fashion reveal systemic problems. Fast-fashion TNCs pollute the environment as company management seek to minimize production costs by placing orders in factories located in developing countries with the lowest costs, where production can often be carried out in emergency conditions, and there is a very high level of pollution (Vladimirova et al. 2020). The concept of fast-fashion involves constant updating of collections (up to 1 time a week), frequent imitation of popular luxury models in much cheaper synthetic fabrics to ensure a low cost of products. Consumers buy clothing made up of synthetic fibers and threads to match the latest fashion trends. As a result, the fashion industry is the second-largest environmental polluter after the oil and gas sector (McFall-Johnsen 2020). Social responsibility and responsibility for preserving the environment should become an essential aspect of fashion companies' activities to improve this situation.

2 Methodology

The methodology used in the article to study the environmental responsibility of fast-fashion TNCs is based on an integrated approach to analyzing socioeconomic systems. An essential aspect of fashion companies' activity is social responsibility, environmental responsibility, and environmental conservation.

This study aims to identify problems regarding the environmental component of the fashion industry TNCs' activities and indicate the difficulties of sustainable fashion methods implementation. The need to reduce the harmful effects of environmental damage contributes to the development of environmentally friendly products.

The analysis was carried out using statistical methods, trend research methods, comparison, and systematization. Conceptually, it was based on emerging Russian and foreign science approaches to analyzing the green and waste-free economy and sustainable development. The authors used statistics from the international (Ellen Macarthur Foundation, Plastic Soup Foundation) and various region- (European Parliamentary Research Service, Institution of Mechanical Engineers) and country-based (United States Environmental Protection Agency, Bremer Baumwollbörse) fashion organizations' analytical information and fashion industry companies' annual reports.

3 Results

3.1 Environmental Situation in the Fashion Industry

The level of pollution, which directly results from fashion companies' activities, is a severe problem. The situation is complicated by overconsumption tendency, characterized by buying more clothes than consumers need, reducing the quality of goods by minimizing production prices, and accelerating trends, which is why the purchased clothes quickly lose their attractiveness and go out of fashion. The authors analyzed the entire cycle of clothing production and consumption to determine environmental pollution's primary sources.

Global production of all fibers increased to approximately 111 million metric tons in 2018, 4 million tons more than in 2017, and 35 million tons more than in 2008 (Preferred Fiber & Materials Market Report 2020).

Most of the fabrics used in the production of fast fashion products consist of chemical fibers and threads. There are two types of chemical fibers and threads—synthetic and artificial (cellulose). Cellulose fibers "are made from chemically treated wood pulp or other natural by-products such as cotton waste and sawdust" these include viscose, modal, and tencel. Mass-produced clothing products are almost entirely made up of synthetic fibers, which include nylon and polyester.

Synthetic fibers are synthetic materials made based on petrochemical products through toxic and energy-intensive processes. The production of synthetic fibers and yarns requires a large amount of oil and is accompanied by the release of harmful emissions such as volatile organic compounds, solid particles, and hydrogen chloride gases. Volatile organic compounds include monomers, solvents, and other by-products resulting in wastewater from manufacturing plants. Many textile industries are extremely environmentally dangerous, so leading companies moved production facilities to developing countries with lower environmental standards.

Synthetic fibers account for more than half of clothing products and 47% of all fiber production worldwide. A significant increase in synthetic clothing production led to an increase in the entire environment's pollution with synthetic microfibres. In 2018, synthetic fibers' global production increased to 50 million tons; polyester yarn alone produced about 45 million tons. The production of artificial staple fiber increased to 22 million tons, and the production of cellulose threads—to 7 million tons (Forecast World Fiber Production 2020).

Of all the fibers, the global production of natural fibers in 2018 was 32 million tons, almost 2 million tons more than in 2008. The share of natural fibers in all fibers and yarns' global production fell from 41% in 2008 to less than 30% in 2018 (Forecast World Fiber Production 2020). Fabric production, including cotton cultivation, requires about 93 billion cubic meters of water each year, while some regions where cotton is grown have water shortages. Cotton requires a large amount of water and heat to grow. It takes up to 20,000 L of water to produce just 1 kg of cotton fiber (McFall-Johnsen 2020). Cotton production creates a considerable shortage of this precious resource. It has dramatic environmental consequences, such as the drying up a significant part of the Aral sea, which is directly related to the overactive consumption of the Syr Darya and Amu Darya rivers for cotton production. 85% of the entire Indian population's daily water demand could be covered by water used for growing cotton in the country (McFall-Johnsen 2020). Although cotton is not an artificial fiber, it is not an environmentally friendly product. Pesticides considered essential for growing plants such as cotton pose a high risk to farmers' health. These carcinogens critically pollute the water supply.

The global textile industry uses more than 120 million tons of non-renewable resources per year, including oil for synthetics production, fertilizers for growing cotton, and chemicals for the production, dyeing, and finishing of fibers and textiles. Chemicals are one of the main components of clothing. They are used in fiber production, dyeing, bleaching, and wet processing of every item. 100 kg of clothing contains up to 23 kg of chemicals (Remy et al. 2016).

The fashion industry generates 20% of the world's wastewater (Kant 2012). A significant amount of freshwater is used for dyeing and finishing clothing. Textile staining is the second-largest source of water pollution in the world. A ton of dyed fabric can take up to 200 tons of freshwater. It takes about 7,500 to 12,000 L of water to produce one pair of regular jeans (McFall-Johnsen 2020). In most countries where clothing is produced, raw toxic wastewater from textile factories is discharged directly into rivers. Wastewater contains toxic substances, including lead, mercury, and arsenic. These substances are extremely harmful to aquatic organisms and the health of millions of people living on these rivers' banks. Pollution also reaches the sea and eventually spreads all over the world. Another critical water pollution source is fertilizers used for cotton production, heavily polluting wastewater, and evaporation water.

The fashion industry also generates 10% of the world's carbon emissions—more than all international air travel and shipping combined (Conca 2015). The share of the textile industry in CO_2 emissions is higher than that of aviation and shipping combined. If current trends continue, the global fashion industry may account for up to 26% of the carbon budget by 2050 (Ellen Macarthur Foundation 2017).

Approximately 1.3 tons of primary raw materials and 104 cubic meters of water per person in the EU were used to produce clothing, footwear, and home textiles sold in the EU in 2017. About 85% of these materials and 92% of the water were used in other regions of the world. The production of clothing and home textiles exerts the second-highest pressure on land use (after food) and causes a significant amount of chemical contamination of water and soil (Ellen Macarthur Foundation 2017).

The production of clothing, footwear, and home textiles for Europeans caused approximately 650 kg of carbon dioxide equivalent emissions per capita in the EU, making textiles the fifth-largest source of carbon dioxide emissions associated with private consumption. About three-quarters of these emissions occurred outside the EU. Synthetic fibers (polyester, acrylic, nylon) used in most fast-fashion products are made from fossil fuels, making the production more energy-intensive than the production of natural fibers. Most of the clothing is made in China, Bangladesh, or India, in countries where coal, the dirtiest type of fossil fuel in terms of carbon emissions, is mainly used to generate electricity. The production of cheap synthetic fibers also releases gases such as N_2O, which is 300 times more dangerous than CO_2.

The fashion industry plays a negative role in soil degradation. Significant damage to the soil is caused by overgrazing of pastures due to cashmere goats and sheep; soil degradation due to the mass use of chemicals for growing cotton; deforestation for cellulose fibers production. Every year, thousands of hectares of endangered and ancient forests are cut down and replaced with plantations of trees used to produce cellulose fibers such as viscose and modal.

Another serious problem for the environment is a significant amount of synthetic microfibers that get into the environment due to machine-washing. About half of the total synthetic microfiber emissions since 1950 (the beginning of synthetic fiber mass-production) occurred in the last decade. About 35% of the microplastics present in the ocean come from synthetic fabrics. In total, up to 500,000 tons of microfibers enter the world's oceans every year due to machine-washing clothes and home textiles (Plastic Soup Foundation 2017). According to researchers from the University of Plymouth, acrylic emits the most microfibers (more than 700,000) during machine-washing; polyester and polyester-cotton mixture emit up to 500,000 and 100,000 microfibers, respectively. These microplastic fibers are so small that they pass through sewage treatment plants and end up in oceans. Fish and other aquatic animals consume microplastic fibers and may enter human food (Institution of Mechanical Engineers 2018).

The overconsumption trend has a detrimental effect on the ecological situation on the planet. The number of clothing in the world has doubled for the last 15 years. According to Greenpeace, about 80 billion clothing items are produced worldwide; it is more than 11 items per person per year (Chung 2016). In some Western countries, the number of purchases is much higher. On average, Americans buy 64 items per year. According to EPA, Americans throw away 68 lb of textiles per person per year (Josephson 2018). More than 60% of surveyed consumers in OECD countries admitted they have more clothes than they need. The life span of clothing has decreased by 36% over the past 15 years. In the US, this period is a quarter shorter than in other parts of the world. In China, the lifespan of clothing dropped by 70% (Reichart and

Drew 2019). Shoppers globally throw away $460 billion worth of clothing that is still appropriate to wear. The amount of clothing that Americans throw away each year has doubled from 7 to 14 million tons for the last 20 years (Special Focus: Textile Recovery 2020).

Excessive consumption and overproduction of textiles lead to an increase in textile waste. Every second, a volume of textile products equal to one garbage truck is thrown into a landfill or burned. In the United States, more than 13 million tons of clothing end up in landfills every year. According to the environmental protection Agency, only about 15% of this volume is recycled (The Woolmark Company 2020). Textile waste in the United States increased by 78% over 20 years, while overall waste volume has risen only by 10% over this period (United States Environmental Protection Agency 2017). However, textile products are made from fabrics and knitwear that have been chemically treated. These chemicals can wash out into open water bodies during the recycling process and, in improperly closed landfills, into groundwater. 84% of unused clothing in the United States was sent to either a landfill or incinerator. The incineration of clothing in incinerators leads to the formation of toxins and their release into the air.

When products composed of natural fibers (cotton, linen, silk) or artificial fibers (viscose, tencel, and modal) act like food waste, producing methane when buried in landfills (United States Environmental Protection Agency 2017).

Synthetic fibers, such as polyester, nylon, and acrylic, have the same environmental disadvantages as plastic. It will take 200–300 years for them to biodegrade. A separate issue is recycling mixed fabrics, as the production of polyester textiles is multiplying (from 5.8 million tons in 1980 to 100 million tons in 2018). There is no efficient closed-cycle technology that recycles mixed fabrics (Miller 2016).

Recycling is rapidly becoming a global environmental issue. By 2050, the amount of waste produced will increase by 70% to 3.4 billion tons. The amount of plastic waste floating in the oceans will increase tenfold. Already, the most massive "dump" is not on land, but in the sea. The largest of these plastic Islands is four times the size of Germany. By 2050, the oceans may contain more plastic than fish (Kaza et al. 2018). Global waste management requires sustainable solutions for waste prevention, efficient disposal, and recycling.

3.2 Environmental Responsibility of Fashion Companies

Limited resources and the growing customers' environmental awareness affect MNCs' activities in the fashion industry and push them to conduct a more environmentally friendly and responsible approach. Many fashion companies take various measures to promote sustainability, implementing initiatives to reduce the fashion industry's negative impact on the environment. In 2018, British designer Stella McCartney teamed up with the Ellen MacArthur Foundation to write the first report on redefining its future.

The reduction of synthetic fabrics (for instance, polyester) would decrease plastic waste in the oceans. In this study, we examined the share of products of leading fast-fashion brands that contain polyester. Under the Uniqlo brand, the share of polyester in products was only 14.3%. Market leaders H&M and Zara do not use much polyester in their clothing, respectively, 18% and 22%. However, a significant part of Vero Moda (60.5%) and C&A (55.7%) dresses have polyester in their products.

Leading fashion brands participate in various environmental initiatives and develop green marketing strategies. Switch to organic cotton produced through environmentally friendly processes remains the most common eco-friendly product initiative implemented by most brands. The Zara and H&M brands have been developing and implementing greener initiatives for several years. Both brands introduced "green" clothing lines with more eco-friendly items H&M Conscious and Zara Join Life. The Zara Join Life clothing line, created in 2016, uses eco-friendly fabrics: organic cotton, Lyocell, or recycled materials. The production of Zara Join Life products needs significantly less water due to new production processes. The release of polluting components was also reduced. The H&M Conscious line, launched in 2011, also uses eco-friendly fabrics (H&M 2020). Both companies have their own set of goals for preserving the planet. H&M Group has implemented the ability to track the path that certain clothing items take from the factory to store, including providing information about the country of manufacture, factory names, and supplier names (Kim 2020). The Monki brand management, part of the H&M Group, aims to create a fully sustainable supply chain by 2030. Representatives of the brand recently announced that all their denim fabrics would be made from environmentally friendly materials (Monki 2020). This decision would positively impact the brand's ecological status, as denim is one of the largest categories of clothing produced.

Outdoor brands implement strategies for developing environmentally friendly products. Sports brands use organic cotton and items made from recycled PET bottles, reducing greenhouse gas emissions. It is worth noting a critical initiative of the Adidas brand to use recycled plastic in shoe production. In 2018, the Adidas brand produced more than 11 million pairs of sneakers from plastic waste. There is a significant increase in Adidas recycled plastic shoe production compared to previous years (only 1 million pairs were produced in 2017) (Adidas 2019).

Another "green" strategy is to use environmentally friendly and biodegradable ingredients: bamboo, beans, charcoal, corn, or volcanic ash. Brands also produce energy-efficient products called "Cool Biz" or "Warm Biz", classified as environmentally friendly products. Many brands also use natural coloring products such as indigo, charcoal, and pomegranate as an eco-friendly alternative.

Closed-loop technology (a process when a product processes into almost the same product) is an enticing prospect for a sustainable approach. However, the development of commercially scalable closed-loop textile recycling technology would still take up to 10–15 years. According to the "Environmental impact of the textile and clothing industry" report, there is a closed-loop technology that allows to take the cotton product, disassemble it, and re-weave cloth; however, after the cotton is dyed, processed, or mixed with other materials, the process will no longer work (European Parliamentary Research Service 2019). Processed cotton, linen, silk, and wool could be mechanically milled for recycling. However, only low-quality short fiber can be obtained using this method. Recycled materials then need to be mixed with the primary fiber to receive cloth appropriate for making clothing. In 2018, H&M brand management faced problems when launching a line of recycled denim made from 20% recycled cotton; a high percentage of recycled cotton led to a lower quality fabric not appropriate for wearing (H&M 2020).

An encouraging trend was demonstrated by Levi Strauss & co in 2018, when Levi's management, in partnership with the textile technology startup Evrnu, released a prototype of jeans made from a mixture of natural and chemically processed cotton from old t-shirts. According to Evrnu, this technology is insensitive to certain dyes; its management declares that jeans will eventually be made from 100% post-consumer cotton waste (Levi Strauss & Co. 2016).

The closed-cycle technology of synthetic fabrics (such as a mixture of elastane and nylon) processing is even further from commercial feasibility. The technology for chemical processing of polyester into its main components and back into the polyester thread exists. The California-based company Patagonia already applies it to recycle its clothing. However, Patagonia is an example of a company that works following sustainable development values, which often requires management to give up additional profits to maximize compliance with environmental standards. The synthetic fabric processing method is excessively expensive and challenging; it requires high-quality polyester textiles (Patagonia's fleece) as raw materials instead of cheap polyester fabrics usually used to produce fast-fashion products (Patagonia 2020).

Guess, a fashion clothing company and jeans brand, announced the beginning of cooperation with i:Collect, which collects, sorts, and processes clothing and shoes from all over the world. The goal of the collaboration is to launch a clothing recycling program in the United States. Customers who bring five or more items of clothing or pairs of shoes will be able to get discounts on the purchase. Items that are still appropriate to wear would be sent to second-hand stores, and the rest would be processed into new products, such as cleaning cloths or fabrics used for insulation purposes (van Elven 2018).

One of the "green" alternatives may be an economically viable clothing rental market. Among the pioneers in this direction is Mud Jeans, which offers organic jeans for rent; other companies joining this initiative are Rent the Runway, Girl Meets Dress, and the Chinese YCloset. The clothing rental model is also appropriate in a luxury segment of the market, for instance, when the consumer needs clothing for events with a dress code, weddings, and other special ceremonies. Rent the Runway and Le Tote have developed up-to-date solutions that meet consumer needs (Rent the Runway 2020). The management of Banana Republic, Urban Outfitters, and Bloomingdale's brands share the initiative to rent clothing; their management already has announced plans to develop solutions based on a user subscription (Chochrek 2019).

4 Conclusions/recommendations

Waste minimization and the transition to waste-free production remain essential issues in the fashion industry that require a unique approach.

The paper includes examples of environmental initiatives implementation at the company level: developing a sustainable supply chain, plastic waste recycling initiatives, creating "green" clothing lines, synthetic fabrics recycling, and others. An important factor in further implementing environmental solutions at the company level is undoubtedly developing proper legislative regulation (legislation improvement is crucial for developing countries' environmental situation, where most productive capacity is located).

Environmentally friendly alternatives need to be introduced in the direct production process of goods and at the stages of operation and processing of clothing. Further improvement at these stages requires working with the client, using the "educational" function of marketing to develop a conscious approach to the process of buying and using goods, moving to the concept of "slow" fashion, which will extend the life of things and reduce the impact of trends on the consumer. Under this concept implies a deliberate approach to the creation of the wardrobe and selection of items.

The stage of clothing recycling is particularly difficult since, at this stage, it is not enough to develop an eco-friendly alternative to existing methods of clothing recycling; it must be user-friendly, affordable, and competitive in order to be widely used. Regulation at the state level also remains a significant factor in successfully implementing eco-friendly clothing recycling options.

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Socially Responsible Investing in the Context of a Green Economy

Svetlana Yu. Pertseva

1 Introduction

Socially responsible investing (SRI) is a relatively new, quickly spreading financial phenomenon, which can be observed in both developed and developing countries. Its allow management to find a balance for the business: to make a profit and meet the social, ethical and environmental requirements of public morality.

Despite its long history, ethical investing is still in its infancy. It is necessary to take care of the planet and to extract not only material benefits but also to promote the development of environmental and social companies began to think mostly in the twenty-first century. Europe and the USA are already actively developing the ethical stock market. The first instruments are just emerging in Russia, and colossal work is needed to improve the financial literacy of the population in the field of socially responsible investments. Soon, social, environmental and corporate factors will be decisive in making both investment and business decisions.

2 Methodology

There are several types of socially responsible investment strategies in the scientific literature (Table 1).

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Table 1 Critical strategies for socially responsible investment (SRI)[1]

Classification	*Description*
Negative/exclusionary screening	The method is applied to exclude specific sectors, companies or practices from the fund or portfolio based on certain factors: environmental factors, social factors and management factors (ESG factors)
Positive/best-in-class screening	Investments in sectors, companies or projects that are selected according to positive ESG criteria and are the best compared to peers in the industry
Norms-based screening	Validating investments against minimum business practice standards based on international norms issued by associations such as the OECD, ILO, UN and UNICEF
ESG integration	Systematic and transparent inclusion of environmental, social and governance factors in the financial analysis by investment managers
Impact/community investing	Targeted investments that address social or environmental concerns, including community investments where capital is explicitly targeted at traditionally underserved individuals or communities, and finance provided to businesses with a clear social or environmental purpose
Corporate engagement and shareholder action	Using shareholder power to influence corporate behavior, including through direct corporate engagement (i.e., communication with senior management and company boards), submitting or jointly submitting shareholder proposals, and proxy voting that is guided by overarching governance ESG principles
Sustainably themed investing	Investments in industries, companies or assets directly related to sustainable development goals (for example, clean energy, green technologies, or sustainable agriculture)

[1] Global Sustainable Investment Alliance Review [Electronic Resource] // GSIA—2018. http://www.gsi-alliance.org/wp-content/uploads/2019/06/GSIR_Review2018F.pdf

In the most common understanding, Eco/Green investing is an investment in companies whose activities do not harm the environment; they improve the ecological situation.

The following data show the scope and dynamics of assets depending on the strategy. Three strategies showed low asset base: sustainable themed investing, positive/best-in-class screening and community investing. Nevertheless, they have shown significant growth over the past two years (Table 2). Positive/best-in-class screening was the leader in terms of assets with a total value of $1.8 trillion, a sustainable investment strategy of $1.0 trillion, influence investments with assets—$444 billion in 2018. The ESG integration showed a decrease in the volume of assets by 24.5% in 2018 compared to 2016.

When making investment decisions, investors choose several criteria that they take into account in their investment strategies. The following characteristics are typical for responsible investment developed by the Ceres fund:

- Sustainable use of natural resources;
- Protection of the biosphere;
- Reduction and disposal of waste;
- Risk reduction;
- Energy-saving;
- Restoration of the environment;
- Safe products and services;
- Management commitments;
- Informing the public;
- Audit and reporting.

The topic of sustainable development has penetrated all areas of activity, including investment. Recently, more and more investors, in addition to

Table 2 SRI assets scope depending on strategy in 2016 and 2018[2]

No	*Strategy SRI*	*2016*	*2018*	*%*
1	Negative/exclusionary screening	248	444	79.0
2	Positive/best-in-class screening	276	1,018	268.8
3	Norms-based screening	818	1,842	125.2
4	ESG integration	6195	4,679	–24.5
5	Impact/community investing	8,385	9,835	117.3
6	Corporate engagement and shareholder action	10,353	17,544	69.5
7	Sustainably themed investing	15,064	19,771	31.2

[2] Global Sustainable Investment Alliance Review. [Electronic Resource] // GSIA—2018. http://www.gsi-alliance.org/wp-content/uploads/2019/06/GSIR_Review2018F.pdf

material benefits, are looking for the ethical component of their assets. By taking into account ESG factors, investors can significantly reduce the risk profile of their investments, which in the long term not only leads to positive risk-adjusted returns but also positively affects all stakeholders. A recent study shows that companies implementing changes to environmental, social or governance standards after attracting investors reaped more than 7% of excess profits after 18 months.[3]

Like any business, ethical investment funds have their pros and cons. The positive sides include a sense of self-satisfaction from doing a good deed, reduced tax rates (funds operating in the UK can invest in individual savings accounts, which allows you to reduce the tax base). Moreover, the global trend of investing in companies that care about sustainable development is pushing their competitors to follow the same direction.

On the downside, there are lower yields; however, according to the latest data from Bloomberg, some funds that adhere to the ESG criteria were performing better than the S&P 500, indicating a positive trend. Market research takes longer, which increases the commission charged by brokers. Unfortunately, this area is developing, so there are not many ethical funds, however, and the choice for investment funds is small.

Socially responsible investment is also worth mentioning the types of mutual investment funds. They divided into categories depending on the degree of social responsibility, the area of investment focus. Consider one of the classifications: light green, medium green and dark green.[4]

Light green funds have the least constraints. Companies involved in the arms trade, alcohol, tobacco, gambling, pornography and nuclear power can be excluded. Still, businesses that use pesticides have low labour policies and sell furs can be included. Soft caps allow light green funds to invest in blue-chip companies, making them the most stable and least risky ethical investment option.

Medium green funds are more restrictive than light green funds. In addition to excluding the same companies as in light green funds, mid-green funds may refuse to invest in companies that have harmed the environment. Because of this, medium-green funds tend to invest in small businesses that, because of their size, are less damaging to the planet.

Dark green funds are the most restrictive and will not invest in any company that does not meet any of the adverse selection criteria. Some funds in this category will only select companies that are actively trying to provide social and environmental benefits. Because of their complete exclusion from big

[3] Going Green [Electronic Resource] // Marketviews—2019, April 15. https://www.marketviews.com/aic/going-green/?utm_source=dianomi&utm_campaign=auto_ads.

[4] Investing in ethical funds [Electronic Resource] // Wattmoney—2017, September. http://www.wattmoney.com/sites/www.wattmoney.com/files/sept_2017_investing_in_ethical_funds.pdf.

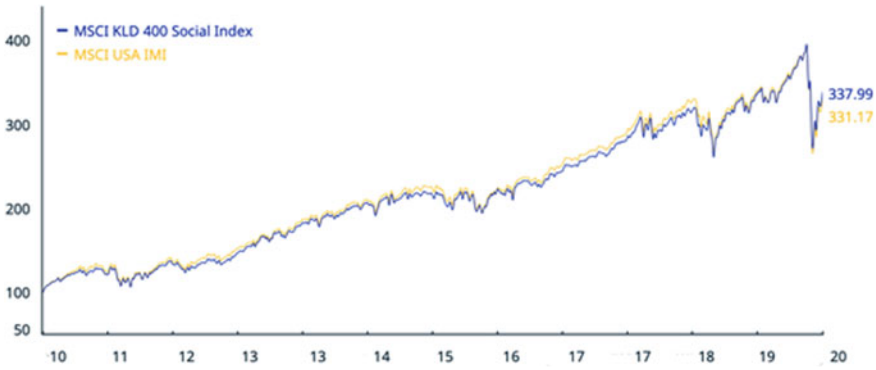

Fig. 1 Return on MSCI KLD 400 and MSCI USA IMI Indices, USD[5]

business and, as a result, fewer stocks to choose from, dark green funds are simultaneously the most ethical and potentially more volatile.

Market participants define and subsequently use the criteria for selecting companies when calculating social indices.

One of the key and comprehensive indices for socially responsible investing is the MSCI KLD 400 Social Index, formerly known as the Domini 400 Social Index. The MSCI KLD 400 is a market capitalization-weighted stock index of 400 publicly traded companies (approximately 250 S&P 500 companies) with outstanding social, environmental and governance ratings. Component selection based on data from MSCI ESG Research. Investors, who seek to diversify their portfolios with strong and stable companies, apply this index. The parent index is MSCI USA IMI, a stock index of large, medium and small companies. Figure 1 presents a graph of the profitability of the MSCI KLD 400 Social Index and its parent index MSCI USA IMI. The chart shows that there is an upward trend in the index yield.

The company selection strategy consists of two stages. The first step excludes securities from companies involved in nuclear power, tobacco, alcohol, gambling, military weapons, civilian firearms, GMOs, and adult entertainment. Then the additions are made from the list of eligible companies based on considerations of ESG efficiency, sector alignment, and size representation. Most of the companies included in the MSCI KLD 400 index are from the information technology sector—30%, communication services – 13.5%, healthcare –11.5% (Table 3).

Also among the major indices is the Dow Jones Sustainability Indices (DJSI) series, which began its development in 1999. DJSI is a family of indices that measure the sustainability of thousands of publicly traded companies and work as part of a strategic partnership between the S&P Dow Jones Indexes and RobecoSAM (Sustainable Asset Management). DJSI contains one primary

[5] MSCI KLD 400 Social Index (USD) [Electronic Resource] // MSCI. msci.com

Table 3 MSCI KLD 400 index asset structure by sector[6]

No	Assets by sector	%
1	Information Technology	30.4
2	Communication services	13.6
3	Health care	11.6
4	Discretionary consumer rights	8.6
5	Consumer goods	8.6
6	Industrial enterprises	8.3
7	Financial companies	8.2
8	The property	3.7
9	Materials	3.1
10	Utilities	2.0
11	Energy	1.9

Table 4 DJSI world asset structure by sector[7]

No	Assets by sector	%
1	Information Technology	25.1
2	Health care	22.9
3	Financial companies	12.1
4	Consumer goods	10.6
5	Industrial enterprises	8.5
6	Communication services	5.9
7	Discretionary consumer rights	4.7
8	Materials	3.9
9	Utilities	2.7
10	The property	2.0
11	Energy	1.6

global index—DJSI World, and various indices divided by geographic regions: Europe, North America, North America and the Asia Pacific.

DJSI World represents the TOP 10% of the 2500 largest companies in the S&P Global Broad Market Index based on long-term economic, environmental and social criteria. Companies related to information technology (25%), healthcare (23%) and financial services (12%) occupy the main share (Table 4).

As for the dynamics of the index, it is inferior to the Dow Jones Industrial Average TR (Fig. 2), in contrast to the previous MSCI KLD 400 index and its traditional analogue MSCI USA IMI.

The demand for sustainable investing is growing. The Sustainable and Responsible Investment Forum (US SIF) showed that more than one in

[6] MSCI KLD 400 Social Index (USD) [Electronic Resource] // MSCI. msci.com

[7] MSCI KLD 400 Social Index (USD) [Electronic Resource] // MSCI. msci.com

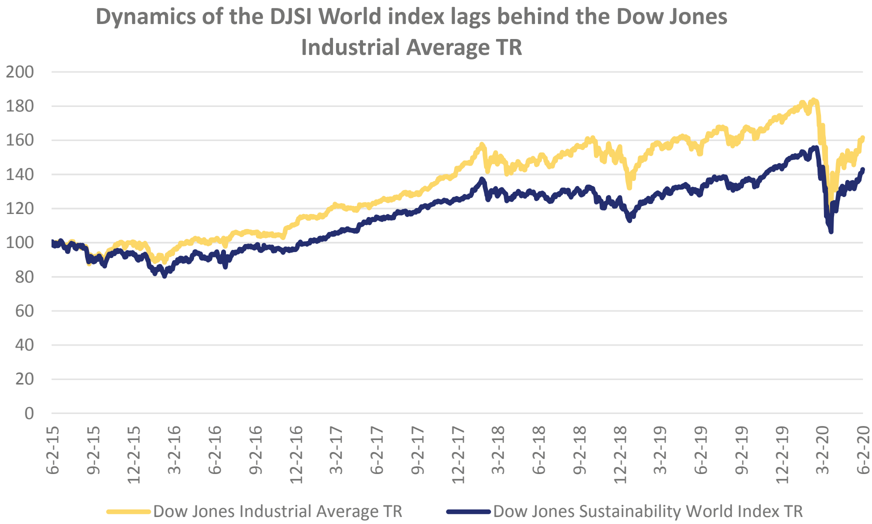

Fig. 2 Dynamics of the Dow Jones industrial average TR and Dow Jones Sustainability World Index TR over five years[8]

every four dollars invested in US capital markets incorporated sustainability into their investment approach in 2018. The number of ethical investment funds increased by 144%, from 115 to 281 in 2004–2018. A record inflow of funding was expected in 288 open-ended and exchange-traded funds available to US investors in 2019. Investments reached $13.5 billion on 09/01/2019. The flows were consistent throughout the year, with sustainable funds raising over $4 billion in each of the first three quarters of 2019. The maximum cash inflow in a quarter was $2 billion.[9]

Survey of individual investors, the Morgan Stanley Institute for Sustainable Investment found that 75% of those surveyed are interested in sustainable investment.[10]

However, the same survey found that 53% of investors believe that sustainable investing requires a financial compromise. This perception seems to cross generations, and 59% of millennials believe sustainable supporting sacrifices financial performance. In line with these results, 76% of American asset

[8] Dow Jones Sustainability World Index. [Electronic Resource] // S&P Dow Jones Indices. https://eu.spindices.com/indices/equity/dow-jones-sustainability-world-index

[9] Sustainable Investing Interest Translating Into Actual Investments [Electronic Resource] // Morningstar—2019, October 30. https://www.morningstar.com/articles/952254/sustainable-investing-interest-translating-into-actual-investments.

[10] Sustainable Signals: New Data from the Individual Investor [Electronic Resource] // Morgan Stanley Institute for Sustainable Investing—2017. https://www.morganstanley.com/pub/content/dam/msdotcom/ideas/sustainable-signals/pdf/Sustainable_Signals_Whitepaper.pdf.

managers surveyed by the institute said they see this perception as one of the biggest challenges to sustainable investing.[11]

Bloomberg's annual ranking of the largest environmental, social and governance funds shows that sustainable investing is a highly demanded activity of the financial market participants.[12] Assets under management of 75 retail funds grew more than 34% to $101 billion in 2019. Socially conscious money managers are betting that sustainable investment will help them find new growth opportunities.

Bloomberg maintains a ranking of successful funds, which focuses on funds with assets of at least $100 million using ESG in their investment process. Since most portfolio managers view the sustainable investment as a long-term bet, the best funds are selected based on their performance, weighted equally over one, three, and five years.

The nine largest ESG mutual funds in the US have outperformed the Standard & Poor's 500, and seven of them have surpassed their market performance in the past five years. The leader in 2019 was the Ave Maria Growth Fund with $878 million in assets, followed by the Calvert Equity Fund (assets: $3.8 billion) and the Putnam Sustainable Leaders Fund (assets: $4.9 billion). All three funds returned over 35%, higher than the S&P 500, which returned 31.5%, including reinvested dividends. The leaders in five-year returns are Morgan Stanley Institutional Fund—International Opportunity Portfolio (MIOPX) and Brown Advisory Sustainable Growth Fund.

The highest performing funds rely on technology and finance companies, which have historically been low-emission sectors. Technology assets including Microsoft Corp., Apple Inc. and Alphabet Inc., and credit card companies Visa Inc. and Mastercard have been the main building blocks of many of ESG's leading funds. Although the pharmaceutical and healthcare sectors were among the worst in the Russell 1000, their assets also hold a significant share in socially responsible funds.

The Bank of America report released in September 2019 predicts a tsunami of assets to be invested in ESG-focused funds. The growth of assets of socially responsible funds is estimated at more than 20 trillion—dollars in the next two decades, which is equal to the amount invested in the S&P 500 funds.

Thus, the direction of sustainable development has a significant impact on mutual investment funds. Many analysts predict growth in the assets of ethics funds and their growing competition for classic funds due to the reduced risks. Moreover, more and more people are worried about saving the planet

[11] Sustainable Signals: Growth and Opportunity in Asset Management [Electronic Resource] // Morgan Stanley Institute for Sustainable Investing—2019. https://www.morganstanley.com/assets/pdfs/2415532_Sustainable_Signals_Asset_Manager_2019_L.pdf.

[12] The Biggest ESG Funds Are Beating the Market. [Electronic Resource] // Bloomberg—2020, January 29. https://www.bloomberg.com/graphics/2020-ten-funds-with-a-conscience/.

and reducing environmental damage, and investors in the future will react accordingly.

The use of ethical and moral principles in investment decisions is on the rise worldwide. Of course, predominantly developed countries are prosperous in this socially responsible investment activity. Still, their influence also extends to developing ones, since most of these ethical investment flows are aimed precisely at improving life, including the most distant corners of the planet.

The performance indicators of socially responsible funds are not inferior to their classical counterparts. The investment is profitable. Besides, it is an incentive for investors to reflect on their investment behaviour and change it towards improvement.

Currently, Russia is witnessing an increase in investments in technologies and projects to protect the climate from hydrocarbon emissions and increase taxes for companies that harm the environment.

There is a growing demand for green bonds to finance businesses with a positive attitude to the environment, and benefits are provided to issuers and holders of such securities. It is necessary to take into account the reputation factor influencing the development of companies investing in maintaining environmental stability. For example, LUKOIL identified 11 UN Sustainable Development Goals as priority ones and funded over 3.5 billion dollars in 2018.

The introduction of the Green Contribution from 03/10/2020 by Center-Invest Bank in Russia can serve as particular examples of the introduction of a green economy. Its main difference is the targeted nature of the placement—the investment funds will be directed to projects that allow achieving the UN sustainable development goals and objectives of national projects. This bank placed green bonds on the Moscow Exchange in 2019.

The total volume of investments in the development of green generation in the Russian Federation in 2025–2030 The Ministry of Economy estimates it at 11 billion dollars s. There are examples of responsible financing and financing of green projects in Russia, but banks are still not sufficiently aware of their principles.

One of the striking examples of the application of green finance is technoparks or science parks. Technopark is an organization managed by specialists whose main task is to improve the well-being of the local community by promoting an innovative culture, as well as the competitiveness of creative business and scientific organizations.

Technoparks are platforms. They create new sustainable technologies. Russia is solving the problem of import substitution and increasing the share of non-resource exports.

Many countries around the world create and finance technology parks. Thus, the Russian Government approved several projects for the creation and development of technoparks in 2018. The legal basis for state support for creating programs is the Federal Law "On Industrial Policy in the Russian Federation".

Now, Russia is developing an infrastructure mortgage mechanism. This lending instrument is as follows: a private partner takes a loan, builds a facility, and the users of this facility gradually repay the loan. Infrastructure owners return funds through regular payments. In addition, budgets of various levels participate in the financing. The use of the mechanism of state guarantees makes the loan cheaper. In the case of an infrastructure mortgage project, a private investor will be able to provide a loan for a road or bridge construction project, or other infrastructure projects, receiving a guaranteed annual income. Such a mechanism will facilitate the implementation of many large-scale infrastructure projects, for example, the sustainable development of Arctic research.

One of the ways to compensate the investor's expenses on infrastructure projects is the mechanism of deferred tax payments, which provides for payments to the investor from future tax revenues from the operation of the constructed facility. This measure will increase the attractiveness of the project for investors.

The first green bonds in Russia appeared in December 2018 to finance environmentally friendly waste management projects. Now the Moscow Exchange has a separate sector for sustainable development. This sector accumulates capital to finance projects in the field of ecology, environmental protection and socially significant projects. The industry consists of three independent segments: the green bonds segment, the social bonds segment and the national projects segment. The choice of tools is still minimal. An infrastructure mortgage mechanism is currently being developed in Russia. This lending instrument looks like this: a private partner takes a loan, builds a facility, and the users of this facility gradually repay the loan. The infrastructure owners return the funds in regular payments. Besides, budgets of different levels are involved in financing. The use of the state guarantee mechanism reduces the cost of the loan. In the case of an infrastructure mortgage project, a private investor will be able to provide a loan for the construction of a road, bridge or other infrastructure projects with a guaranteed annual income. Such a mechanism will facilitate the implementation of many large infrastructure projects, for example, the sustainable development of Arctic research.

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The first green bonds in Russia appeared in December 2018 to finance projects on environmentally sound waste management. The Moscow Exchange has a different sustainable development sector. This sector accumulates capital to finance projects in the field of ecology, environmental protection and socially significant projects. The industry consists of three independent segments: the green bonds segment, the social bonds segment and the national projects segment. However, the choice of financial instruments is limited, and there is not enough liquidity.

3 Results

As a matter of fact, SRIs make a significant contribution to the development of a green economy. Governments of the countries of the world, management of corporations, individuals are aware of their responsibility to future generations in terms of ensuring environmental safety and preserving the environment.

The financial market offers a significant arsenal of methods and tools for the growth of green investments. The demand for these tools is continuously growing. Consequently, the amount of financial resources allocated for the implementation of environmental projects and protection from environmental risks is increasing.

States are making significant efforts to stimulate the development of green finance. They create a regulatory framework, infrastructure, regulatory institutions.

Analysis of world experience shows that developed countries have a rich history of SRI creation and development in the context of a green economy. They have developed financial markets, a large number of investment instruments and significant amounts of liquidity. These factors provide an influx of investors from all over the world.

Demand for environmental ratings is growing as investors place increasing emphasis on relevant risks when making investment decisions. According to experts, the total volume of the global green bond market increased from \$3.1 billion in 2012 to \$829 billion by April 2020. There are more than 700 issuers on the markets, including not only companies but also the state.

Investors' demand for the environment also affects the cost of borrowing for the issuer: green bonds are cheaper in terms of both coupon and total yield. The difference is 1–2 basis points. The issue of such securities is a more costly process compared to the issue of classic bonds. The reason is need to the need to confirm the environmental friendliness of the investment project.

In Russia, a specialized Sustainable Development Sector appeared on the Moscow Exchange in August 2020. Securities of Russian and foreign issuers that meet the principles of green or social financing are presented on this exchange. At the moment, there are only seven bond issues of four issuers in this sector. The Moscow Exchange classified the issues of the following issuers as green securities: Bank Center-invest (issue volume—250 million rubles), FPC Garant-invest (500 million rubles) and SFO Rusol 1 (three issues in total for 5, 7 billion rubles). The other two issues in the sector are social securities issued by the Social Development Federal District.

The problem today is the lack of the necessary liquidity on the domestic market. In the West, institutional investors, in whose hands the central liquidity is concentrated, perceive the environmental friendliness of the paper as a signal to increase the share of investments in its issuer. In Russia, this factor is not yet decisive.

The Russian SRI market has a short history. Despite a wide range of challenges in instruments, investors and infrastructure, it has high growth potential.

According to the author, SRI is a crucial development trend in the modern global economy. In the future, this segment of the financial market will develop at a rapid pace.

4 Conclusions

In conclusion, it should be emphasized that the number of socially responsible investment funds is increasing every year. Developed countries are the drivers along the way.

The financial instruments for ethical and traditional investing are the same. Some SRI funds and indices outperform traditional instruments in terms of their performance. The reason is that ethical funds avoid many of the risks inherent in their classic counterparts. This quality becomes valuable in the face of financial crises and uncertainty.

In Russia, mindful investing is not as popular as abroad. Reasons: low financial literacy of the population, a high share of oil and gas companies in investment portfolios, low demand for sustainable development tools from both investors, companies and the state. Despite this, the Russian Federation has already taken its ft.

Ethical investment has enormous potential, which changes the perception of investing and placing funds to a qualitatively new level that brings profit, and creates comfortable conditions for further sustainable and conscious development.

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Development of Russian Energy Companies and Renewable Energy Sector in Russia

Nikolay V. Studenikin

1 Introduction

The Russian Federation has extensive potential in the development of renewable energy, a significant part of which is currently hydropower and biomass power generation. Biomass energy and large hydropower plants are key renewable energy sources in the Russian Federation. Russia also has great opportunities to develop solar and wind power generation. The capacity of wind power generation projects that will be launched in Russia by 2025 will exceed 3.2 GW. The total growth of "green" generation will be 5.4 GW of new capacities. The share of wind power generation in the unified energy system of Russia should exceed 1%. The Government is allocating 231.2 billion rubles for its development in 2022–2035.

2 Materials and Methods

In this work, the author uses statistical research methods, including correlation, based on data from reports on development of alternative energy in Russia as well as comparative and institutional analysis. The author also uses the methodology of economic and comparative analysis of industrial enterprises' activity in the RES sector.

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3 Results

According to experts, in about two decades, society will need 30% more energy (Rodionov 2017). This is due to the development of the world economy, the increase in the number of people living on the planet, the improvement in quality of life and consumption. In the energy sector, there is a rapid development of the latest technologies, which significantly reduce energy intensity. The energy market is increasingly being taken over by Green Technologies. In the last five years, 1 trillion dollars have been invested in the global green energy industry, and at present there are around 10 million jobs in this sector.

Based on data from the International Renewable Energy Agency (IRENA), by 2030 about 40% of the electricity generated will come from clean energy, which is almost twice the current market share (Rodionov 2017).

The Russian Federation has extensive potential in the development of renewable energy, a significant part of which is currently hydropower and biomass power generation. Biomass energy and large hydropower plants are key renewable energy sources in the Russian Federation.

From 2016 to 2019, the installed capacity of HPPs in Russia actually reached 48 GW, which is more than 20% of the total generation volume of 236.3 GW (*Main characteristics of the Russian electric power industry. Ministry of Energy of the Russian Federation*). Small and medium-size HPPs have only 280 MW of electricity generation capacity.

The classification of HPPs in Russia is as follows: small—up to 5 MW; medium—from 5 to 25 MW; large—over 25 MW. The largest HPP is Sayano-Shushenskaya (Republic of Khakassia) with a capacity of 6.4 GW (*PJSC RusHydro*). In total, there are over 100 HPPs in Russia with a total capacity of over 100 MW.

The era of large-scale hydropower development in the Russian Federation dates back to the Soviet Union, namely from the 1930s. At present, the largest producer of electricity based on water is RusHydro PJSC, whose assets include about 90 hydroelectric power plants. Despite the fact that hydropower is developing rather rapidly, about 80% of the economic potential of this resource in Russia is still untapped due to the remoteness of these areas and poor infrastructure. However, the potential for the development of HPPs in Siberia and the Middle East will not only provide relatively cheap electricity to people in remote areas, but will also allow them to be exported to countries in the Asian region.

Biomass energy is the second largest source of electricity generation in Russia, with plant capacity of 1.35 GW. The development of technology to generate electricity through the use of biomass is related to the abundance of forests and agricultural waste in the Russian Federation.

The key resources for generating energy from this renewable energy source are fuel pellets or pellets, which are extracted from wood waste, peat and recycled agricultural raw materials.

Despite the potential of this energy resource, Russia lags far behind the key suppliers of this type of raw material to Europe at 0.9 Megatons (hereinafter referred to as Mt), while the leaders are the USA (4.6 Mt) and Canada (1.6 Mt). The largest importers are the United Kingdom (6.5 Mt), Denmark (2.1 Mt) and Italy (1.6 Mt). In the Asian market, the main biomass importers are South Korea—1.5 Mt and Japan—0.2 Mt. The total volume of imports of raw materials for electricity generation through this type of RES in the EU countries is 13 Mt.

While the prospects for technology development in this area are quite clear, a key barrier for the Russian Federation in terms of biomass exports to the EU is its underdeveloped infrastructure. For example, the largest producer of pellets in Russia is the Vyborg Timber Corporation, which owns a plant in the village of Sovetsky (Leningrad Region). The production capacity of this plant is 1 Mt. Other plants are located to the east of the largest pellet production in Russia. This raises the problem of transporting raw materials for further export (Proskurina 2017).

In addition to these sources, Russia is also developing technologies to generate electricity from the Earth’s energy, namely geothermal energy. Russia has impressive reserves of geothermal energy, which by various estimates are 13–15 times greater than the proven volume of organic fuel deposits. The use of geothermal energy prevails in Kamchatka, Western Siberia and the North Caucasus, which is directly related to climatic conditions. For example, experts estimate that the potential of this type of cogeneration plant in Kamchatka could reach 1000 MW (Zubareva 2016). It is also noteworthy that the majority of geothermal power plants in Russia are designed with binary cycle technology in mind. Geothermal power plants of this type use the technology of pumping cold water inland to produce hot water, but when using the binary cycle, the water received goes not to the evaporator but to a heat exchanger where most of the heat energy is transferred to another liquid. In this way, the “binary liquid” is used separately from the thermal water and increases the efficiency of the plant by increasing the duration of the power generation cycle and reducing harmful emissions into the atmosphere.

Geothermal energy is divided into two subtypes, namely hydrothermal and petrothermal. The latter is characterized by the fact that energy is extracted from dry rocks at great depths at the corresponding high temperatures, as the average temperature with depths rises by 2.5–3 oC for every 100 m. Hydrothermal energy is based on the use of steam, water vapour mixtures and groundwater heat and is the most common due to technical difficulties in obtaining electricity when developing petrothermal sources.

In Russia, the petrothermal energy potential is 100 times higher than that of hydrothermal energy, about 3.5 thousand against 35 trillion tonnes of reference fuel. It is also important to note that heat pump technology has a number of advantages which, among other things, will contribute to the fact that Russian residents will be able to use land energy for heating their homes, even if they live in underdeveloped infrastructure areas.

In contrast to traditional sources, RES are largely dependent on a territorial factor, and therefore their installation primarily takes into account the climatic conditions of a particular region. In Russia, for example, SES and HES are distributed in southern regions, while HES and GeoTES are distributed in the East. However, the predominant part of RES installations is built in the vicinity of densely populated areas concentrated in the European part of the Russian Federation. This is due to the development of network infrastructure in these areas.

On a global scale, the solar and wind energy industry is currently seeing an increase in the number of small companies developing their production technologies. A similar global trend is associated with the introduction of new standards and subsidies for this area, as many countries have committed themselves to reducing their emissions since COP21 was signed. However, this situation is more typical of developed countries that have the technological basis for innovation, which reduces the cost of their creation. In most cases, as in Russia, RES production is carried out by companies established with the support of state or semi state structures. In the Russian Federation, the most striking example is OOO "Havel", whose projects will be discussed further. The company was initially established as a joint venture between OAO Rusnano (49% of shares) and GK Renova (51% of shares) in 2009.

By way of comparison, SunPower (USA) is a company that also carries out similar projects, but has a wider geography of operations. In the initial stages, SunPower was a "startup" company that was organized to create photovoltaic technology. In 2011, the company became part of the Total Group. At present, the company is not only one of the largest exporters of solar cells, but also creates technologies for the largest US government agencies. SunPower's revenue in 2016 alone amounted to 2.56 billion US dollars, with an annual growth rate of 20–30%.

At first glance, solar power in the Russian Federation is a rather underdeveloped and unpromising industry, which is associated with natural conditions and the lack of a sustainable technological base for its development. However, according to studies by the International Renewable Energy Agency, Russia has great potential for the development of this source, including through the vast areas that are favorable for the construction of a solar power plant. In summer, solar radiation in the southern territories can reach 6 kWh per square meter per day, while during the whole year this figure is 3.5–4.5 kWh per square meter per day. On average, the annual potential for solar power generation in these regions can exceed 1200–1500 kWh per year, while in Germany only 600–750 kWh.

In 2016, the installed capacity of solar and wind power plants in the Russian Federation was 591 MW. As mentioned earlier, solar power plants dominate this volume, which is distributed in the southern territories, while wind power plants are a rather underdeveloped power generation resource. The problem in this case is not related to the lack of wind power in a given region or to the lack of technology that major foreign investors are currently willing to provide, but to the lack of a sufficient legislative basis for the development of WPPs.

Wind energy accounts for the smallest share of electricity production in Russia—55 GWh per year. Wind energy investment in Russia from 2013 to 2016 amounted to 103 billion roubles—1.8 million USD, which is quite a low figure compared to China's investment in this industry in 2015—47.6 billion USD.

The capacity of wind power generation projects to be launched in Russia by 2025 will exceed 3.2 GW. The total growth of "green" generation will be 5.4 GW of new capacities. The share of wind power generation in the unified energy system of Russia should exceed 1%. The Government is allocating 231.2 billion rubles for its development in 2022–2035. In comparison, 138.8 billion rubles are planned for solar power generation in the same period, and 30 billion rubles are planned for supporting small hydroelectric power plants. The share of wind power generation in Russia's unified energy system should increase from 0.07 to 1%. Currently, the capacity of wind power plants (WPS) in Russia's UES is 183.91 MW. By 2036, the country should achieve parity between renewable and conventional power generation, after which alternative generation can be developed on a rolling basis.

The climatic conditions in the Russian Federation are one of the key obstacles to the creation of power generation projects. Representatives of large companies engaged in the production and distribution of hydrocarbons and the development of power grid infrastructure use the natural characteristics of the state to develop their own business, but due to the underdeveloped infrastructure, the end user has to pay overcharged rates for the electricity received. This is due to the fact that most power plants in Russia's eastern regions use diesel fuel, which is quite expensive to transport.

The key problems in satisfying electricity demand among consumers living in areas with no centralized heating system include the high level of energy losses during generation and the low efficiency of diesel power plants (20–25%), high equipment wear and tear, overestimated electricity costs (Shakirov et al. 2013). To address these problems, the management of the Far East regions took a number of measures aimed at reducing the use of diesel for electricity generation, but due to the energy crisis, the price of this raw material increased significantly, which offset all the measures taken. In this case, wind power can be one of the main sources of meeting the demand for electricity from consumers, including in remote areas. However, the severe climatic conditions prevailing in most of the Russian Federation make the introduction of renewable energy technologies much more difficult. Imports of high-tech equipment are also becoming a barrier due to the small number of production facilities for this type of technology.

In Russia, this barrier can also be overcome, as exemplified by distributed energy (cogeneration) projects in Yakutia. The first German-made wind turbine, manufactured in 1993, was installed in the Republic of Sakha in 2000. Between 2007 and 2015, wind power plants in the village of Tiksi saved around 96 tonnes of hydrocarbon fuel by generating over 486,000 kWh. A project to create the following is currently under development 5 wind-diesel stations and 83 solar installations in Tiksi based on wind power plants manufactured in Japan. The corresponding Agreement was signed in 2015 between the management of the Republic of Sakha, PJSC RAO UES East and KOMAIHALTEC Inc. At the design stage, Russian specialists modernize and refine foreign technologies for their further operation in extreme conditions. This practice can be used in the development of other joint projects, which demonstrates the possibility of overcoming existing barriers in this area.

Exports of electricity to China should be singled out as an incentive to develop wind power in Russia, particularly in the eastern regions. Electricity can be transferred to Heilongjiang and Jilin provinces, which are currently experiencing serious pollution problems. The Government of the Russian Federation has already put forward an idea to attract investment in a joint Russian-Chinese project to generate 50 GW of wind power on land in the Far East for further export. However, this project has not been implemented (Shumkov 2018) to date. In addition to China, Russia is also able to export wind power to Europe, which will create a kind of synergy between the 2 regions of the world and thus help to attract new technologies to the renewable energy sector.

At the current stage, the development of RES is creating a number of positive externalities for other energy and industrial sectors, in particular, the introduction of energy-efficient technologies in production will not only help to reduce energy costs, but will also increase the number of jobs. For example, in the production of solar cells in China the number of new jobs has increased to 1.7 million, in the entire RES sector of China this figure was 3.5 million, in the United States—800 thousand. Thus, the gradual development of the RES sector will also to some extent solve the problem of unemployment in remote areas of Russia, as well as attract foreign specialists for staff training.

It is important to note that the process of improving the existing RES base requires large investments primarily in research and development and the establishment of research centers to study issues related to increasing the energy efficiency of installations and reducing financial costs for their production and operation.

R&D is an important aspect in the development of the RES sector due to its high technological capability. Innovation is quite risky because, depending on the type (incremental, breakthrough and subversive) and depth of impact, it can reduce the capital costs of producing a particular technology—incremental, or make a qualitative increase in innovation potential on existing technological capabilities—breakthrough. Subversive innovations cannot simply improve a product, but can completely replace it with a less capital-intensive and more efficient one. Thus, by developing the technological base of RES, the Russian Federation will be able to reduce the cost of producing elements for power plants in the short or medium term.

An important step towards the development of renewable energy in the country is the creation of centers of competence, as well as domestic production. The Competence Centers will allow not only to accumulate foreign knowledge about a particular source of renewable energy, but also to provide consulting services for manufacturers. Plants for the creation of elements for renewable energy power plants will contribute to a significant reduction in installation costs. The cost of photovoltaic and wind turbines produced abroad is relatively high and amounts to USD 7–9 per 1 W of energy. Thus, the price of a solar plant with a capacity of 5 kW will be in the range of USD 7–9 per 1 W. 25 to 35 thousand US dollars. Therefore, their payback period may be quite long (about 25 years).

According to the experience of other countries, the expansion of the technological base for the construction of renewable energy installations in the Russian Federation will lead to a gradual reduction of production process costs.

According to estimates of the Russian Ministry of Energy, as a result of the annual competitive selection process for renewable energy projects up to 2020, the maximum amount of investment may reach 466 billion rubles for the entire period. According to a more optimistic assessment by the International Renewable Energy Agency (IRENA), Russia could increase the share of RES in the energy mix from the current 3% (excluding large hydropower) to 11%. In order to exploit this potential, an annual investment of US$ 15 billion is required. This will require an annual investment of $15 billion up to 2050.

It is important to note that the development of renewable energy in Russia is strategically important not so much in terms of increasing power generation as in the development of related innovative, science-based and capital-intensive technologies that are complementary to renewable energy projects. Another promising niche is the creation of hybrid energy complexes—autonomous energy facilities consisting of several alternative energy sources (gas piston plant, wind power generation, solar power plant, electric energy storage).

4 Use of Public–Private Partnership Mechanisms for Creating Renewable Energy Facilities

In Russia, due to a number of restrictions, the number of PPP projects in the field of renewable energy is still low. According to expert estimates, the most convenient and promising legal form for launching PPP projects in the renewable energy sector is concession agreements. In the current economic conditions of the market, construction of facilities is mainly carried out under capacity supply agreements (CSAs), which imply a fixed tariff. The application of the PPP mechanism may become attractive to the market if the format is changed, i.e. the energy is not transferred to the common grid and the number of participants is expanded.

In 2014, a 40 kW solar power plant facility was commissioned in Eik, Yakutia. The solar power plant was built in addition to the existing diesel power plant and consists of 160 single-crystal modules. The settlement belongs to an inaccessible area with 350 inhabitants. Due to its geographical location, there is a problem with the delivery of raw materials, especially from December to April, when winter vehicles are formed in the absence of roads. A decision was taken to sign a concession agreement between Olenskiy ulus and OAO Sahaenergo to implement the project to supply heat to the village.

Also in the regions, a number of projects are being implemented on the basis of PPPs for the installation of autonomous hybrid diesel-solar power plants with a capacity of up to 1 mW in the Trans-Baikal Region (costing RUR 20.3 million), construction of small hydropower plants in the Republic of Altai (RUR 3.2 billion) and construction of small hydropower plants in the Republic of Altai (RUR 3.2 billion).In the Sakhalin region, 2 geothermal power plants are under construction (860 million rubles each).

In addition, there are a number of biomass processing projects to supply the population with electricity. For example, one of the first projects was implemented in 2014. RosTeplo has completed a concession agreement with the administration of the Kovrov district of the Vladimirov region. As part of the agreement, the company was to provide replacement for two fuel oil boilers in the village of Nerekhta and in the village of Shevinskaya. The subject of the agreement was the reconstruction of the boiler plant (partially financed by the concedent) with the transfer of ownership of the management and collection of user fees for a period of 7 years and the corresponding transfer of the constructed boiler plants to the public side. The concessionaire built two boiler houses, which operated with chips of natural humidity. The volume of investments amounted to 64 million rubles, each boiler plant cost 32 million rubles. During the operation of the facility, the money invested by the Concessionaire was returned through the collection of tariff payments. As a result, annual savings from each boiler plant amounted to over 7 million rubles.

5 Brief Description of the RES Projects of the Leading Companies in Russia

5.1 Rosatom Corporation

Rosatom entered the wind energy market in 2016. According to Rosatom experts' estimates, by 2024 its volume may reach 3.6 GW, annual turnover—1.6 billion dollars. It's estimated that by 2024 it could reach 3.6 GW of annual turnover of 1.6 billion USD. This will guarantee demand for the production of wind turbines (Wind Turbines) and the design of wind farms, the necessary infrastructure for them and technical support services.

NovaWind is a new division of Rosatom designed to consolidate efforts in advanced segments and technological platforms of the power industry. It was founded in 2017 with a charter capital of RUB 1.101 billion. At the initial stage, NovaWind consolidated all of Rosatom's wind energy assets and is responsible for implementing the Wind Energy strategy.

Rosatom's first wind farm, the Adygeya wind farm, has already been put into operation. The wind power plant consists of 60 wind power plants with a capacity of 2.5 MW each, and the installed capacity of the wind park is 150 MW.

Rosatom is currently implementing a programme to build WPPs at four sites in the Stavropol Territory and Rostov region. The next wind park will appear in the Kochubeyevsky district of Stavropol and will consist of 84 wind power plants of 2.5 MW each, which is a major wind park under construction in the country by 2020. In addition, construction has already begun on the Karmalinovskaya wind farm with a capacity of 60 MW and the Bondarevskaya wind farm (120 MW) in the Stavropol Territory, as well as the Marchenkovskaya wind farm in the Rostov Region, which will have a capacity of 120 MW.

5.2 RUSNANO Group

RUSNANO Group is a state corporation that implements the state policy on nanoindustry development, acting as a co-investor in nanotechnology projects with significant economic or social potential.

In 2018, Rusnano contributed to the active development of green energy in some areas (e.g. the Far East) through a concession. The main idea was to force the regions to enter into concession agreements for the payback period of green projects, as well as to transfer green power generation under bank loans.

The investor will replace inefficient diesel generation with renewable energy sources, or combine diesel and renewable energy, and the tariff will be subsidised from the region's budget until the return on investment. The region will act as an end user, which will receive savings due to the fall in subsidies following the modernisation of generation. For projects with a payback period of 8–12 years, long-term tariffs will be fixed, taking into account the minimum profitability, and for projects with a payback period of more than 12 years, additional income and property tax benefits will be offered.

Rusnano co-founded a special investment fund, the Wind Energy Development Fund, which was created by partners to invest in the construction of wind power plants. The fund is managed by Wind Energy Management Company owned by Fortum PJSC (owned by the Finnish corporation Fortum) and Rusnano Management Company LLC in equal shares.

As a result of competitive selection of investment projects for the construction of renewable energy generation facilities, the FWR was awarded the right to build 1,823 MW of wind power. Wind farms are to be put into operation before 2024. The amount of investment is about 15 billion rubles.

In 2020, it was announced that VTB, Gazprombank and Sberbank would provide a syndicated loan to the Wind Energy Development Fund for the construction of the fourth wind power plant in the Rostov region, the Kozachey Wind Power Plant with a capacity of 100 MW. It is noted that the project is being implemented on the principles of project financing and envisages the provision of loan funds against a guarantee of future cash flows under contracts for the provision of capacity for renewable energy generating facilities.

The first phase of the 50 MW Cossack Power Plant is planned to be commissioned by the end of 2020, and the second phase will be commissioned in the fourth quarter of 2021. The volume of investments is about 60 billion rubles.

In the first half of 2020, three power plants were commissioned in the Rostov region—Sulinskaya, Kamenskaya and Gukovskaya—with 100 MW each.

The portfolio of projects implemented in the Rostov and Ulyanovsk regions consists of four HPPs with a total capacity of 350 MW and projects with a total capacity of 745 MW are at various stages of implementation.

5.3 Rushydro Group

RusHydro Group, one of the largest Russian energy holdings, is a leader in the production of energy from renewable sources, developing generation based on the energy of water flows, sea tides, wind and geothermal energy.

As part of the Renewable Energy Development Programme, RusHydro is implementing wind energy projects in the Far Eastern Federal District. In 2013–2015 3 wind power plants were commissioned in Kamchatka region and 1 wind power plant in Sakhalin region, the total installed capacity of the plant was 2,175 MW. A wind power plant was also commissioned in 2013 in the Yamalo-Nenets Autonomous District.

JSC "Sahaenergo" (part of RusHydro Holding) successfully operates 21 SES with a total capacity of 1,606 MW. In 2015, as part of an agreement with the Government of the Republic of Sakha (Yakutia), the largest polar solar power plant with a capacity of 1 MW was built in the settlement of Batagai in the Verkhoyansk district of RS(Yakutia). The Batagai power plant is also listed in the Guinness Book of Records as the northernmost solar power plant in the world.

"Rushydro will commission a small hydroelectric power plant (SHPP) with a capacity of 5.25 MW in the Stavropol Territory by the end of 2020. This plant will be the third small hydropower plant built as part of a programme to support the development of green energy. The first two projects under this programme—also small hydropower plants—were launched this year in Kabardino-Balkaria and Karachay-Cherkessia.

By the end of 2020, it is planned to commission a third small HPP at Barsuchkovskaya MPP with a capacity of 5.25 MW in the Stavropol Territory. On 10 November 2020, the Ust-Dzhegutinskaya small HPP with a capacity of 5.6 MW was commissioned in Karachayevo-Cherkessia. The company estimates that the average annual power output of the Ust-Dzhegutinskaya HPP will exceed 25 million kWh.

Geothermal energy in Rushydro is represented by the existing power plants in Kamchatka (Pauzhetskaya geothermal station, Verkhne-Mutnovskaya and Mutnovskaya GeoTPPs are part of a subsidiary of Kamchatskenergo).

5.4 Hewel Group

Hewel is the oldest Russian company operating in the solar energy industry. It was founded in 2009 as a joint venture between Renova Group and Rusnano. An investment agreement was signed on 4 June 2009 to establish production of solar modules in Russia. The Company built the first full-cycle plant in Russia to produce solar (photovoltaic) modules and the first industrial-scale power plant. In total, more than 100 projects with a total capacity of over 611 MW have already been implemented by the Group.

One of the first projects of GC "Havel" and the landmark for the state projects in the field of renewable energy, implemented with the support of the Ministry of Energy, was the Kosh-Agach Solar Power Plant—one of the largest solar power plants in Russia and the most powerful (after Kosh-Agach SES-2) power plant of the Republic of Altai (10 MW), commissioned in 2014. The power plant project was selected following the results of the competition for renewable energy projects in the wholesale electricity and capacity market in 2013. The solemn ceremony of launching the Kosh-Agach Power Station, in which Russian President Vladimir Putin took part (via teleconference bridge), took place on 4 September 2014.

One of the successful solutions and promising areas of renewable energy sources is the rooftop solar power plant (RES) in the Chelyabinsk Region in order to save electricity from the grid.

An enterprise producing high-voltage electric motors—Joint Stock Company Russian Electric Engines (JSC EED) (a subsidiary of Transneft). In 2017, this was the largest project of the Group's roofed solar power plants for industrial facilities. The project took 8 months to complete, and in February 2018 a 240 kW rooftop solar power plant was erected at the plant's production building under construction. The project is unique in that it is the only solar power plant currently installed on the roof of the plant's production building in the Chelyabinsk Region. It is interesting that the cost of energy production was 2.98 roubles per kilowatt per hour (based on the operation of the plant for 25 years).

An indicative trend in the Russian renewable energy market is the planned merger of assets between T Plus and Havel. This creates a major joint venture in the solar energy sector—the merged company is estimated to be worth up to 133 billion rubles. The consolidation of the assets is expected to be completed by the end of 2020. Tplus's share in the joint venture is tentatively estimated at 15–16%. The total capacity of the joint venture will be approximately 1.5

GW, including facilities built, under construction and existing generation facilities. "T Plus, through the JV, will participate in the selection of investment projects within the framework of the green energy support programme (state programme PSM RES).

Another indicative trend for the prospects of the Russian renewable energy market is the development of industry associations. On 29 September 2020, an Agreement on Cooperation between the Russian Association of Small Energy and the Russian Wind Industry Association was signed. Cooperation between the two professional organizations will be aimed at stimulating the development of small distributed energy industry in Russia and joint implementation of innovative energy projects.

6 Conclusion and Recommendations

According to expert estimates, the development of renewable energy in Russia will remain rather slow in the coming years. However, lower costs for the production of renewable energy and power generation units, as well as reduced demand for hydrocarbons, will lead to a situation where the Government will have to force the development of this sector. In this case, the key problem may be the lack of the necessary mechanisms to expand the existing base and the interest of key investors.

In our view, the Government needs to implement measures to develop the renewable energy sector in Russia:

1. to contribute to the expansion of the regulatory framework in this area, in particular, to the development of regulation of the microelectric power sector, which is promising for renewable energy;
2. increase funding for programmes to introduce renewable technologies in the country's retail and wholesale markets, taking into account the best practices of the EU countries (primarily Denmark and Germany) and North America (the USA and Canada);
3. in order to improve the renewable energy sector, to support the deepening of cooperation between the state and private companies with a special interest in the development of renewable energy technologies, both at the national and international level;
4. to extend the state mechanism of the RESPF by another 10 GW between 2024 and 2035, but with stricter requirements for investors: the capital costs at the tender should be reduced as much as possible. At the same time, industrial support measures for the sector should be formed, ranging from exports to retail market support;
5. to provide information support and promotion of renewable energy in the constituent entities of the Russian Federation interested in reliable and uninterrupted power supply to the population of remote areas;

6. to implement energy management systems in remote areas based on the best foreign and domestic practices in the field of renewable energy, and to develop institutional cooperation in this area.

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On the Mechanisms of Pharmaceutical Pollution of the Environment Risk Reduction

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1 Introduction

The necessity of coming up with efficient ways of improving ecological safety of Russia's regions is an extremely relevant issue in the circumstances of large-scale environmental pollution with industrial, household and technogenic waste. The list of issues which have been becoming more and more important recently includes the following: providing ecological safety of pharmaceutical production, control of medical substances and medications use (both by healthcare facilities and population), appropriate utilization of expired medications. At first look it seems that healthcare facilities and pharmaceutical enterprises control production, testing and implementation of medicaments used for treating humans or animals. Those institutions carefully study efficiency and safety of various medications, thoroughly practice and analyze ways of their use, constantly monitor patients condition with the purpose of evaluating medication effectiveness and detecting troublesome side effects experienced by the patients taking medications (both in long- and short-term prospects). A lot of attention is given to the issues of pharmaceutical productions waste release regulation, rules and forms of control of medicaments purposeful use and utilization. International norms are introduced into the national legislation in the field of pharmacy eco-safety. There are as well

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methods of analysis and estimation of facilities ecological safety (Kuznetsov, 2010). It seems that the work on making pharmaceutical sector safe and finding effective ways for expired and out-of-demand medicaments utilization is going to achieve its ideal goal. But numerous research (i.e. Kolpin et al., 2002; Santos et al., 2010; Richards et al., 2004) show that produced medications at some point make their way into the environment, making huge impact on biota and eventually coming back to the human with food, air and water. This results into repeated circulation of medication elements in the system «human – medication waste in dumps and sewers – surface and sub-soil waters – irrigation sources of plant products capable of accumulating medications during their growth – meat and milk products (with veterinary medications) produced with the use of plant food and/or polluted water – drinking water (quite often not purified enough and thus containing secondary medication elements) – human and so on». From this circulation scheme we can see how huge the chemical-pharmaceutical load for the environment is (first of all for water resources).

Naturally, a question rises, and the question is: if there are any ways of decreasing ecological safety risks connected with massive medication elements emission into the environment and its negative impact? But before we move to defining mechanisms and ways of increasing the level of ecological safety from pharmaceutical medications and elements, let us analyze the sources and ways for pharmaceutical pollution, single out principal biological risks and shape principal approaches to minimizing those risks.

2 Background and Methodology

Analysis of medications way into the environment allows us to single out two main groups of pathways transporting mediations into biosphere. It's either disposal of expired or out-of-demand medications and pharmaceutical elements by dumping them (actual dumps or sewers); or emission of medication into the environment after it being a subject to certain (complete or partial) metabolic transformations in human body, after which those elements are naturally emitted into sewers system.

According to pharmaceutical economics experts from various countries from 35% up to 50% of produced medications turn out to be out of demand and, eventually, dumped. The reasons are excessive sales of medications, low demand, expiration, violation of production, storage and transportation norms and regulations. For instance, according to the data by National Pharmaceutical Association in the USA only there are more than 220 tons of medications dumped annually (Kozyrev et al., 2012); and the population alone disposes of up to 100 tons of medications annually. More than 120 tons of medications per year are dumped by USA hospitals and healthcare facilities. According to the on-hand data (Onischenko, 2009) there's more than 1,3 million tons of hazardous and extremely hazardous medication waste accumulated annually in Russia, with more than 65 thousand tons being medication waste produced by healthcare facilities. This waste belongs to G category (highly toxic substances).

As it was mentioned before, medication elements make their way into the environment after being actively used by patient. After making its way into human's organism a part of medication undergoes metabolic transformations and often loses activity. The other part of medication stays unchanged (50–90%) and is transported by blood system (mostly) to the necessary organs and tissues. If we consider 65–70% of medication doses staying unaltered and if we take into consideration the fact that human's organism only uses about 60% of medication taken, we can conclude that almost 40% of medications taken by patients are emitted into the environment non-transformed.

We have to point out that the main source for pharmaceutical pollution is not used medication, emitted into the environment by sewers, domestic sewage and emissions from dumps containing non-utilized medications which are out-of-demand in individual households as well as in hospitals and healthcare organizations. The second biggest source of pharmaceutical pollution is medication and medication substances naturally coming out from organisms of patients as non-used or as results of metabolic transformations. Finally, water pollution and agricultural irrigation, as well as veterinary medications, pesticides and other substances aimed at supporting the life cycle of plants also contribute to pharmaceutical pollution a lot. All those factors eventually lead to noticeable increase in the level of pharmaceutical pollution of not only surface, but also subsoil waters. Existing sewers waste treatment facilities typically use only basic water processing means, such as chlorination and ozonation, which allows to remove only about 50% of pharmaceutical elements and metabolites. But they are unable to solve the issues with purifying sewer waters from medications and metabolites to full extent, as they are not designed for capturing or decomposing pharmaceutical elements.

As a result of numerous research in the field of pharmaceutical pollution of the environment (and, first of all, of open water basins and drinking water sources—Richards et al., 2004; Cotruvo et al., 2012 and others) it's clear that more than 80% of water samples contain detectable amounts of biologically active substances of various nature, including various pharmaceutical substances such as antibiotics, anti-inflammatory medications, statins, synthetic hormones, antiepileptic drugs and so on. The samples would often contain up to 10 and more of such elements; some samples would show simultaneous presence of 50–60 medications and biologically active substances.

At the present moment in most cases levels of detected pharmaceutical medications in drinking and non-drinking water sources are moderate and can hardly have any negative impact on human. This is true to a certain extent for those regions of the Russian Federation which have no chemical-pharmaceutical industries and thus primary sources of pharmaceutical pollution in those regions are population and healthcare facilities. However, presence of pharmaceutical industries in certain regions, where pharmaceutical accidents occasionally happen or where violations of ecological legislation of the Russian Federation have place, lead to emergence of polluting chemical-pharmaceutical emissions which have exclusively local nature and present certain danger only for certain regions.

Nevertheless, such circumstances as rapid production growth and implementation of new medicines, implementation of a huge quantity of highly-biologically active medicines, emergence of selective medications aimed at selective pharmaceutical correction of «harmful» cells functions, selective termination of internal parasites all lead to a noticeable increase in the level of ecological risks of pharmaceutical pollution aggravation—primarily in terms of pollution surface and subsoil waters.

This results into increase of pharmaceutical elements and waste concentration in surface and subsoil waters (these are both well-studied and new substances, whose effectiveness, biological activity and metabolic transformation processes are not studied enough yet). All this eventually leads to a noticeable emergence of relatively new ecological risks of ecological pollution and, consequently, to more and more negative ecological impact on human.

As Kozyrev, Korablev and Yakutseni point out in their work from 2012, in modern world there are no standards regulating levels of medication elements in water. Water purification systems are not designed to control presence of medication elements, there are no mechanisms that would allow to estimate the impact that low concentration of various pharmaceutical elements in drinking water make on human's health in long-team perspective. All the things mentioned, considering the fact we know much more about the presence of pharmaceutical polluters than we know about their long-term impact (which is often distorted by a lot of other chemical, physical of social factors, which have their own impact on human's body), it's safe to say that we are dealing with one of the most hazardous and systemic ecological risks. It's necessary to add that these risks have negative tendencies to rapid development and aggravation.

One of significant factors of ecological risks, which can lead to serious diseases, is the risk of undergoing combined impact of numerous pharmaceutical substances and their metabolites which are in chemical interaction with each other. This can produce effects of mutual potentiation of substances, change of «dose – effect» ratio for a certain pharmaceutical combination; this often also leads to change of character of therapeutic impact of various combinations of medications. There are known examples of situations when simultaneous presence of two medicines in a human's body would enhance their biological activities in more than a hundred times. Presence of such effects leads to considerable decrease of ecological safety reserve of pharmaceutically-contaminated environment in case of complex influence of a group of medication accompanying substances. We have to point out that at the present moment there are no methods of forecasting estimation of the impact medications and their metabolites, found in the atmosphere, make on human. Getting relevant and accurate experiment results is extremely complicated and often just impossible due to high level of temporal and dimensional variability of concentrations and names of pharmaceutical substances (Richards et al., 2004; Cleuvers, 2003).

One of the negative aftermaths of pharmaceutical pollution is environment's influence on human, which happens through ecology of water environment having undergone detrimental impact of medication and pharmaceutical substances waste. For example, even relatively small concentration of non-steroid anti-inflammatory medication diclofenac (0,5–1,0 ppb) in surface water basins for 4 weeks time leads to emergence of cytological changes in kidneys, liver and gills of trout fish (Cleuvers, 2003; Schwaiger et al., 2004). And these kinds of fish are ones of the regularly eaten by human. Another detrimental ecological factor is relatively high concentration of antibiotics in water environment, and it's worth noticing that those medications stay non-degraded for a long period of time. The reason for this is wide use of medications in veterinary. Presence of antibiotics in water environment has detrimental effect on self-purification processes in water and soil; relatively low concentration can result into appearance of bacteria resistant to antibiotics and able to cause human diseases. Pharmaceutiacally polluted water environment, as well as biosphere in general, can also be a home for processes of medication substances and their metabolites relocation and accumulation in food chains of plants, animals and, eventually, humans. Medications are different from ecotoxicants as they are artificially created biologically active substances which are able to reallot in tissues of living organisms. What it means for biota is that medications, their metabolites and waste dissolved in water environment can possibly directly concentrate within certain tissues of plants. Concentration can at the same time reach levels close to therapeutic dose. The result is non-zero possibility of transportation of medication substances within «plant food – human», «plants – animals – meat and dairy products – human», «fish – human» chains; there may also be a chance for direct transportation of medication substances within «water – water treatment system – human» chain.

The aforementioned negative ecological aftermath of pharmaceutical pollution leads to a number of biological risks for human who is, due to living nearby areas and water basins, contaminated with medication substances and thus forced to use those substances and medications because of their presence in the environment—in the air, in the soil, in the water, in plants and, eventually, in food. Even relatively low concentrations of these (often toxinogenic and biologically active) substances and medication waste possess a lot of kinds of therapeutic impact and, being delivered into an organism via either respiratory system, digestive tract or skin, start intensive interaction with each other as well as with functionally-important molecular components of those body tissues they are in, which causes adverse physiological and biochemical processes in those tissues.

3 Results

It's obvious that composition of medication accompanying substances and medications found in the environment is to a large extent determined by: regional peculiarities of certain territorial formations of Russia; presence or absence of chemical and pharmaceutical industries in the area; population density in certain regions and, consequently, population dispersion among the biggest cities in the region; number of dwellers, population composition, medical orientation of healthcare institutions within the region. Level and degree of pharmaceutical pollution often depends on season of the year, water saturation level and other geographical peculiarities of the area.

The analysis of the issues of medication supplying system (Kozyrev et al., 2012) shows that while dealing with the issues of creation, testing, producing, storing, supplying and implementing medications, the medication supplying system does not really have an ecological component aimed at detecting and isolating potential ecological and biological risks connected with pharmaceutical pollution of the environment with medication waste, out-of-demand and expired pharmaceutical substances and products of metabolic transformations of used medicines. There is also the problem of medications which are not used and consequently emitted into the environment by healthcare facilities and, especially, population.

We would like to offer certain insights and mechanisms which would allow us: to detect possible ecological and biological risks caused by mass pharmaceutical pollution of the environment; to prevent possible negative ecological impact of pharmaceutical industries; to solve the issue of effective utilization of expired and out-of-demand medications by both medical institutions and population.

The direct mechanism aimed at estimation of ecological risks of pharmaceutical pollution with new medications is Pharmaceutical Surveillance Service «Pharmaconadzor» (a sub-unit of Federal Service for Surveillance in Healthcare (Roszdravnadzor)). It is known (Glagoev and Asetskaya, 2016) that Pharmaceutical Surveillance Service activity is aimed at «examining the effectiveness and safety of a medication's «life cycle»—starting with laboratory tests, pre-clinical tests on animals, pre-registration clinical research and the time it's on the market». We can see that one of the main tasks of Pharmaceutical Surveillance Service is, while controlling the use of new medications, not only detecting detrimental side effects, but also: detecting complications connected with inappropriate use of medications under control; estimation of how efficiently medications are used; detecting facts of adulteration and, probably, one of the most important tasks—studying to what extent controlled medications can affect the ecology. It's worth noticing that currently the task of estimating medications eco-impact is not being executed well enough. Of course Pharmaceutical Surveillance Service carries out toxicological evaluation of new pharmaceutical substances before implementing them into clinical practice, examines the impact of combined medications containing controlled pharmaceutical elements and enhancing medication of therapeutic nature on patient, analyses the process of metabolic transformations of new medications. All this allows certain degree of prediction on how new medications and combined medications will behave in case they are emitted into the environment. However, these tests don't give a full answer to the question of degree of ecological safety when the «life cycle» of medications ends with non-utilization—when they're spontaneously or consciously emitted into the environment as a pharmaceutical accompanying substance. To deal with this problem it makes sense to expand powers and field of activity of Pharmaceutical Surveillance Service by introducing a laboratory of examination and estimation of negative ecological aftermath in case of controlled medication pollution laboratory.

Next mechanism aimed at controlling possible consequences of pharmaceutical pollution is Ecological monitoring of natural environment quality centres (Volkova, 2017), which are introduced in accordance with Chapter 6 of the Federal Law 7 «On the Environment Protection» in every sub-federal unit of the Russian Federation. The centres normally provide laboratory support of ecological watch in corresponding regions, including hydro-chemical and geo-chemical monitoring of pollution, as well as air pollution control. Such laboratories have certain technical and instrumental capacity, initially oriented at taking all-around ecological tests of water, soil and air environments, and thus can be used for researching the level of pharmaceutical pollution with the purpose of making scientifically-reasoned recommendations for organizing utilization processes of non-used and expired medications.

The third (and, probably, the most important) mechanism for decreasing ecological risks causes by pharmaceutical environment is the mechanism (or, to say it better, mechanisms) of pharmacological waste utilization by hospitals and other healthcare facilities as well as by the population. In the Russian Federation the mechanisms of pharmacological waste utilization by healthcare facilities are regulated by the regulatory legal acts (Prozherina, 2017): Sanitary Regulations and Norms 2.1.7.2790-10 «Sanitary-Epidemiological Requirements For Medical Waste» (edition of 01.01.2019), the Russian Federation Law «On Protection of the Environment» from 10.01.2002 № 7 (edition of 01.01.2019), The Russian Federation Law «On Sanitary-Epidemiological Well-Being of Population» from 30.03.1999 №52 (edition of 26.07.2019), the Russian Federation Law «On Production and Consumption Waste» from 24.06.1998 № 89 (edition of 19.07.2019). The mentioned documents present a list of organized events needed for dealing with waste in general and medical waste in particular; they define the way waste should be utilized; describe the technique for working with such type of waste; establish essential ways for decontamination of utilized medical-biological and pharmaceutical substances; describe basic rules for safe use of such ecologically and biologically-hazardous substances. However, it should be taken into consideration that there is no universal and optimal way of decontamination of medical waste, but there are two definite principles of utilization—selective collecting of medical waste and its substantial decontamination in terms of epidemiological risks and ecological protection (Scherbo and Mironenko, 2013). Both worldwide and Russian environment protection practices pay a lot of attention to the issues of decontaminating and neutralizing medical waste (for example, Getman and Nerkevich-1, 2013; Huber et al., 2005), at the same time the main direction for development of utilization systems of non-needed and expired medication substances and other medical-biological waste of healthcare facilities is the establishment of de-centralized systems of neutralization of waste and hazardous medical substances in places of their formation (Akimkin et al., 2015).

Particular attention should be paid to the issues of utilization of population-produced pharmaceutic waste. Number of countries (Australia, the United Kingdom, the Netherlands) have positive experience of establishing receiving centres (usually set up in drug stores) where population can utilize non-needed of expired medications for the following utilization. The problem of utilization of non-needed medications in the Russian Federation has not been resolved yet, thus it requires to be addressed both on state and local, regional, municipal levels.

One more important and effective mechanism of decreasing pharmaceutical pollution is domestic sewage purification (Getman and Narkevich-2, 2013). At the present moment there are no industrial technologies of purification which would allow total purification of water from pharmaceutical substances. However, there is a number of purification technologies which, nevertheless, allow to substantially decrease the concentration of pharmaceutical substances is water. In particular, there is such technologies as: use of activated carbon, oxidation and ozonation, coagulation, membrane filtering and others (Getman and Narkevich-2, 2013). Unfortunately, not only of the mentioned technologies can be applied for sewage purification due to their high cost.

4 Conclusion

A well-developed healthcare system, raise in life expectancy, medication accessibility, high concentration of people in metropolises are the main factors leading to annual increase in the pollution of the environment with pharmaceutical substances and their mutagens. This anthropogenic phenomenon is actively studied in various countries of the world where a number of practices are shaped and implemented in order to protect ecology.

Practices aimed at decreasing the level of pharmaceutical substance concentration in general waste and healthcare facilities and population waste, control of the non-controlled pathways for pharmaceutical substances into the environment will naturally contribute to improvement of ecological situation and preservation of homeostasis in biological populations. Eventually implementation and expansion of the mentioned mechanisms of decreasing pharmaceutical risks of water, soil and air environment contamination will lead to decrease (both in quality and quantity) of composition and concentration of pharmaceutical substances making their way into human's body with water, plant food, fish, meat and dairy food.

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Humanization of Production Based on Modernization: The Perspectives of Industry 4.0 for Corporate, Social, and Ecological Responsibility

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1 Introduction

A term "Industry 4.0" has gained popularity in recent years, being first presented by the president of The World Economic Forum Klaus Schwab in his book "The Fourth Industrial Revolution" (Schwab, 2016). Today this term has become a synonym to the period of modernization of the world community under the influence of information technology.

Production modernization in technological revolution is being is carried out in three main directions: system integration, intelligent edge and automation. During which the part of quantitative elements of the economic growth is diminished and the priority is given to enhancing its qualitative elements. The given research deals with an analysis of the activity of a large national oil company in terms of meeting the conditions of "The Fourth Industrial Revolution: Industry 4.0". The aspects of influencing the climate and environment were also studied in the analysis.

A public joint stock company (PJSC) "Surgutneftegas" was chosen as an example for the research. For a long while according to national media group RBK this company is top five in volume of produced crude oil and is marked as a company with an open and innovative policy and a precise adherence

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to the principles of sustainable development and to the requirements of the environmental legislation within international conventions and agreements.

2 Methodology

The theoretical background is based in the works of Russian and foreign scientists: K. Schwab (2016), E. Knight (2014), Costantini, V., Monni, S. (2008) etc., annual reports of international organisations, conferences and European Commission data and Institute of Scientific Communications. The subject of the research was the open data on the activities of "Surgutneftegas".

The methodological background of the scientific research includes: formal logical method, systems analysis of the output levels. An inference analysis was implied for receiving the overview of the logical derivations and the results of the research.

3 Results

The activities of oil companies were relevant as a source of economy growth especially in countries with commodity economy by providing stability. In Russia oil and gas companies are at the centre of energy facility as well as a resource of life support for people. The percentage of people involved in this industry is very high and because of that the "mission" undertaken by the company which is to improve the quality of employees' lives, releasing intellectual and professional potential is reflected in in the company's income and social-economic development of the given region. Various social benefits such as financial support for improving quality of life are reflected in the status of an appealing and responsible employer.

Oil company "Surgutneftegas" is one of the major companies in the industry (Fig. 1) and in terms of the variety of provided data is relevant for analysis and research from the point of view of following the international trends. The volume of produced oil and gas in 2019 amounted to 60,8 million tons and 9,6 billion cubic meters (Fig. 2) respectively and this is the third result in in-country rate.

Modernization of production by implementing information technologies reflects not only in the company's income but also in corporate-social responsibility, environmental security and safety, which is a policy's priority. For sustaining modern levels of development that is a necessary requirement for durability (Knight, 2014) the company extensively implements cutting edge technologies and materials n all stages of production. It allows achieving goals in security and environmental friendliness of the production and is vital for sustaining and acquiring competitive advantages. Moreover technological modernization encourages employees to enhance their level of education required for the given sphere. This shows the necessity of the intellectual modernization (Sultanova and Chechina, 2016).

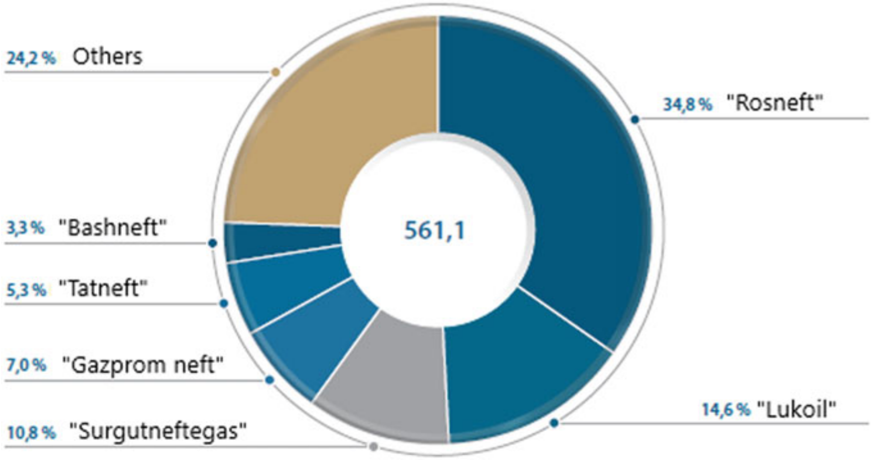


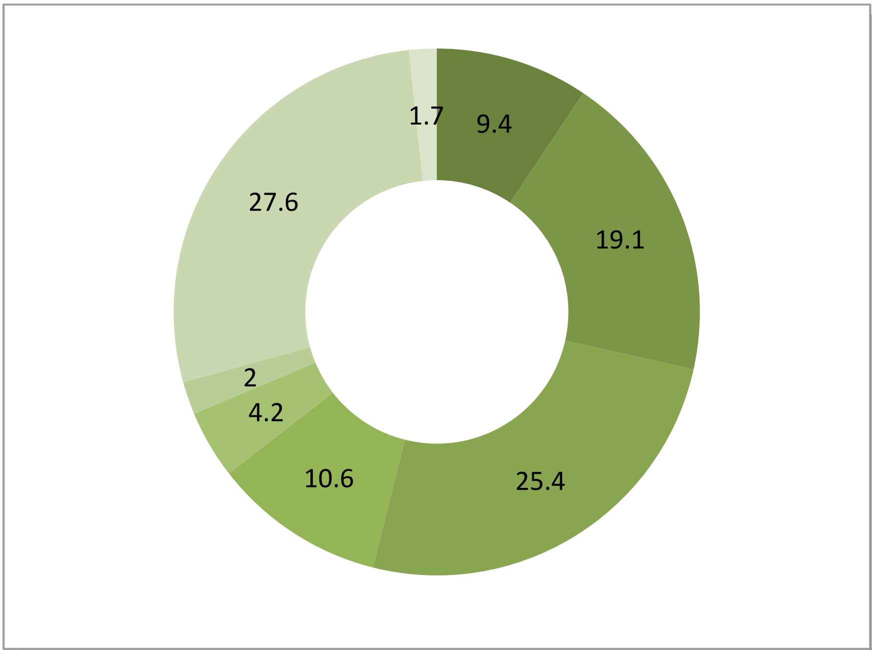
Fig. 1 Shares of the volumes of oil produced in 2019 (*Source* Taken from "Surgutneftegas" 2019 annual report)

Innovation is actively funded. In 2019 approximately 32 billion rubles were spent on that sphere and more than 3,5 thousand employees were involved including automation of the production cycles, enhancing the effectiveness of management and impleneting robots in diagnosing and repairing of pipelines and oil and gas installations according to annual report (Balance Sheet, 2019). At this time the costs of innovation activity in "Rosneft" (Annual Report, 2019) amounted 30 billion rubles while the revenue in 2019 amounted 8.6 billion rubles which in percentage is 2.06% CIS and 0.4% Rosneft (Table 1).

4 Modernization of Production in Ecology

Consider a more detailed programme of modernizing the production and a humanization effect logically related to it. The implemented programme of innovative update is related to activities targeting the reducing of material and labour-intensive consumption of the production, enhancing the effectiveness of usage of the fixed capitals. The concomitant programme of cost reduction is aimed on the sphere of main and ancillary production (up to 82% of all expenditures dedicated by the programme), partly drilling (up to 16%) and only 1% of the optimization reached economic and social spheres. Due to the fact that drilling of oil wells the main company's activity and is characterized as an area of extensive costs and responsibility. The social sphere of is one of the policy's priorities and in this case the reducing of expenditures in significant quantities is impossible. This fact once again shows the significance of social-corporate responsibility for the company.

According to annual report (Druchinin, 2019) the company patented 4 specialized programmes for digital monitoring production and shipment of



Building of environmental protection facilities	9.4
Environmental safety of oil refineries and equipment	19.1
Sewage collection, treatment and disposal of wastewater	25.4
Safe waste management	10.6
Prevention and management of oil pollution, rehabilitation of production facilities	4.2
Environmental monitoring	2
Protection of ambient air and prevention of climate change	27.6
Research on environmental education for staff	1.7
Total, billion rubles	29.4

Fig. 2 Financing of environmental activities in 2019, in% (*Source* Compiled by: Taken from annual environmental report 2019 of NK "Surgutneftegas")

Table 1 Indicators of expenditure on innovations of Rosneft and Surgutneftegaz

	Surgutneftegas	*Rosneft*
Revenue	1.555 billion rubles	8.676 billion rubles
R&D	32 billion rubles	30 billion rubles

Source Compiled by Taken from "Surgutneftegas" and "Rosneft" 2019 annual report

gas and oil in "Rospatent". Implementing information systems in technological process allows receiving objective and reliable data on the condition of the facilities, central access and storage for subsidiary companies' specialists. Digital technologies also ease the efforts of employees working with massive data sets and decreasing the time of transmission not only shows the data in real time but also reduces sector-specific, environmental and financial risks.

Considering these events from the humanization point of view enhancing working conditions and safety of the employees, especially ones who are involved in hazardous production are also noteworthy. This implies excluding risks caused by cold climate and remoteness of objects, injuries by damaged machinery, frostbites and possible damage from encounters with wildlife. Automation and digitization of the production process reduce physical exertions intensity and work hours and predict dangerous events.

Considering prompt launching of new oil wells and conservation of used ones from the humanization point of view it is important to note the environmental situation. Using newest materials and technologies allows preventing a used oil well becoming an emergency one as it happened before. Disruption of cement in casing string, metal corrosion causes oil to spill on the ground surface. In large volumes they cause occurrence of bodies of water, salinity and eutrophication which as a result damage the environment.

Implementing new oil wells is accompanied by disasters followed by ecological risks. Moreover drilling process is preceded by a long lasting process of preparation; paving access roads, multiple well platforms for the future oil well, electrification of the area preceded by installing power lines and other engineering facilities. All this types of works influence the environmental balance. For preventing and minimizing of which the company implemented 112 facilities for preliminary sewage collection, 6 facilities for cleansing soil and 3 facilities for clearance of sludge, a facility for working with anticorrosive coatings and others. The full list is depicted on (Fig. 3). The expenses on environmental activities totalled 29,4 billion rubles.

Following the results of 2019 the company was awarded with Environmental transparency rating by WWF together with international company Creon Group.

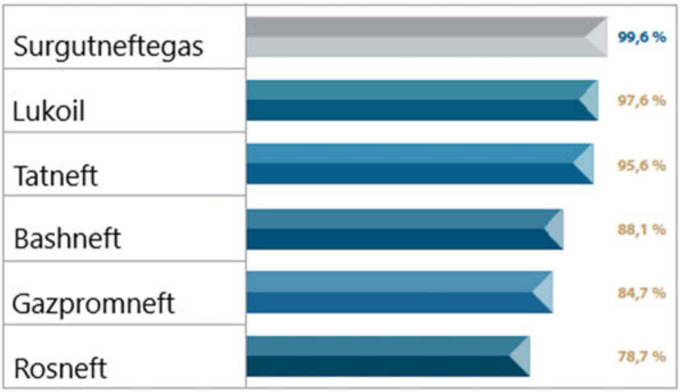


Fig. 3 APG utilization rate of Russian oil companies in 2019 (*Source* Compiled by: Taken from "Surgutneftegas" 2019 annual report)

5 Climate

To prevent global climate change "Surgutneftegas" is implementing a policy targeted on oil gases waste management which when burning emit greenhouse gases such as CO2 and methane in the atmosphere. Joining "Kyoto protocol" serves as an incentive for fighting the climate change for Russian Federation. The initiative of the World Bank "Zero routine flaring by 2030" targeted on governments of countries, oil companies and development institutes made the energy industry meet the requirements of UN in terms of sustainable development.

Today the rate of recycling the associated petroleum gas (APG) in the company is 99,6% (Fig. 4) this is the highest rate among national oil companies and it stays on this level since 2013. This rate shows high expertise and overall development of the sphere. According to reports on the world's flaring of the associated petroleum gas USA, Russia and Venezuela have reached a significant progress (Global Gas Flaring Tracker Report, 2019).

High results in recycling of APG are achieved by well-structured recycling system where the majority of the gas is sent to a gas processing factory for future recycling, just under a quarter is used for producing energy and about 15% is spent on technological needs. These numbers ones again show the environmental friendliness of the company.

The World Bank points out that according to the table above Rosneft is the largest producer of liquid oil and the fact that the company has the lowest rate of recycling APG is a constraint for it to stay at the world level.

Legislation, international programmes and fines are the main instruments in for reaching ecological policy's efficiency. According to Chapter 8 Federal Law No.141 the responsibility on legal persons for violations related to damaging the environment. Since 2019 a huge change was made by halting the company for 90 days which even more increased the responsibility among companies.

	Measurement	2019
Oil production	million tones	60,8
Gas production	billion m^3	9,6
New oil wells	wells	1 286
New injection wells	wells	617
Personnel	men	112 795
-oil production		101 653
-oil refining		7 783
-marketing		3 359

FINANCIAL PERFOMANCE

Revenue	million rubles	1 555 623
Cost	million rubles	1 071 836
Net Profit	million rubles	105 479

Fig. 4 “Surgutneftegas” activity (*Source* Taken from “Surgutneftegas” 2019 annual report)

For comparison in European countries ecological crimes are enlisted in criminal codes (German Criminal Code, 2020) taking Germany as an example. In doing so the violations od not imply restrictions of liberty of the ones responsible. Similar policy is implemented in USA, Canada and Norway.

A survey among the heads of large oil companies conducted by Deloitte in 2017 proved the imperfection of the legislation in the given industry.

6 Conclusion

Analysing the ecological policy of “Surgutneftegas” in terms of the world rates provided by international organisations, programmes and projects it should be noted that the company has a high rate of implementing the environmental policy, in particular:

- Modernization of the production meets the requirements of humanization and the human needs and developing human capacity;
- The company endorses and implements international trends in protecting and recovering the environment;
- Events held by the company prevent the climate change and meet the government’s demands and are rated as relevant to the world level by the World Bank.

The fact that Russia has reached high results in recycling APG but the rates of harmful emissions shows that it may be worth improving the legal framework. Increasing penalties for violations in the environmental area, strengthening the control over production will oblige the companies struggling to meet the conditions to improve their policy.

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Financial Strategy of Energy Crisis-Management of Regional Economy in Industry 4.0 for Security

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1 Introduction

The strategic vision for the development of the energy economy is related to its progress in two directions. The first direction: transition to energy 4.0. The main point of this direction in the context of the general digital modernization of the economy is to automate production and distribution processes in the energy sector as much as possible. Thanks to automation, improved control of the value chain, monitoring of energy consumption, forecasting of demand and supply (production capacity and labor productivity) in energy production is achieved.

The second direction: achieving energy sustainability. In the long term, this direction involves significant energy conservation and the transition to alternative—cleaner and renewable energy. In the short and medium term, the

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essence of this direction is to maintain the lack of energy services, that is, to fully meet the demand for them.

Although these areas arose separately, their synthesis is taking place in the practice of modern energy markets. As the digital economy grows, the need for energy resources increases, potentially met by the growing production capacity of energy 4.0. In fact, large-scale investments in energy 4.0 initially lead to higher costs.

In an effort by energy companies to recoup their investment in digital innovation as soon as possible, they are raising energy prices. The problem is that prices in the energy markets of many countries are regulated by the state, which, in particular, is characteristic of Russia. As a result, the financial performance of energy companies (profitability) may deteriorate due to increased costs, which may cause a decrease in the volume of electricity production and supply, that is, energy crises.

As a hypothesis, this article suggests that the increased risk of energy crises in the 4.0 industry is characteristic of the regional economy of Russia, which impedes security. The purpose of the article is to develop a financial strategy for the energy crisis-management of the regional economy of Russia in the 4.0 industry in the interests of security.

2 Literature Review

A literature review showed that the overall risks of transition to industry 4.0 as a threat to the security of the digital economy are determined by Inshakova et al. (2020), Chaldaeva (2019), Guseva et al. (2019), Abramova et al. (2019). Non-equilibrium, energy market collapses and energy crisis management issues are disclosed by Kalu et al. (2020), Popkova and Sergi (2021), Popkova et al. (2019a, b), Ruostetsaari (2020), and Saraswat and Digalwar (2020).

At the same time, the gap analysis showed that the financial aspect of the strategic energy crisis-management, as well as the peculiarities of its implementation at the level of the regional economy and in the context of industry 4.0, is practically not worked out in the available scientific literature. This gap leads to the lack of a scientific, methodological and empirical basis for the development and implementation of financial strategies for the energy crisis-management of the regional economy in industry 4.0 in the interests of ensuring security, in particular in Russia. In recognition of the need to fill this gap, the subject area of the present study has been identified.

3 Materials and Method

In order to reflect the experience of regions with the highest level of economic security, this study is carried out on the example of the top 10 regions of Russia on the socio-economic situation at the end of 2020, that is, at the beginning of 2021 (in accordance with RIA Rating, 2021) as a determining factor of economic security. The characteristics of economic security and energy

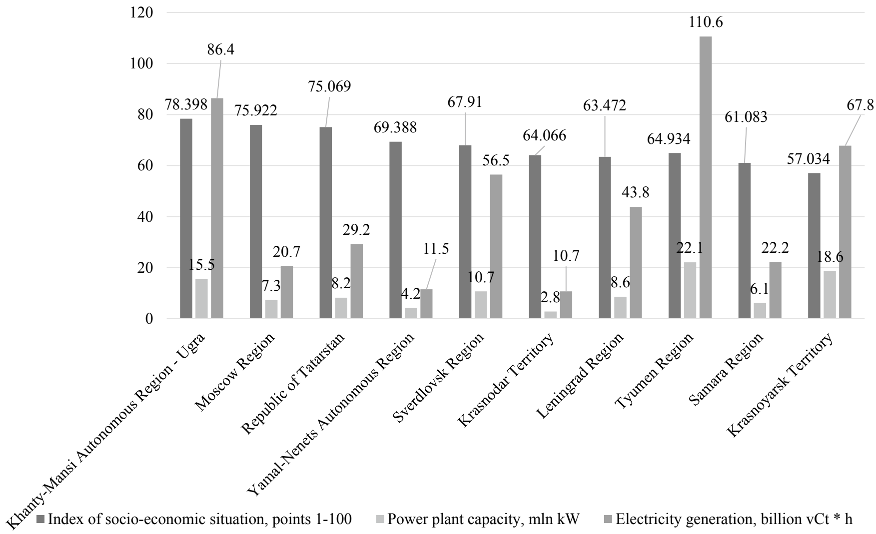

Fig. 1 Characteristics of economic security and energy development in the regions of Russia from the sample in 2021 (20212021 *Source* Built by the authors on the basis of the materials RIA Rating [], Federal State Statistics Service [])

development in the regions of Russia from the sample in 2021 are given in Fig. 1.

The logic of the research involves the definition of regression dependence:

1. Volume of shipped energy products (E) from the profitability of assets (ra) and provided energy services (rs) as indicators of the financial efficiency of energy services, according to Federal State Statistics Service (2021);
2. Profitability of assets (ra) and provided services (rs) to provide energy from the level of digitalization (dg) based on the materials of the Institute of Scientific Communications (2021).

The hypothesis is considered confirmed in case of detection of direct dependence of E on ra and/or on rs and simultaneous with this inverse dependence of ra on dg or rs on dg. Statistics on the volume and financial efficiency of energy services, as well as the level of digitalization in the top 10 regions of Russia in terms of economic security in 2021 are given in Table 1.

4 Results

In order to establish quantitative links between the financial efficiency and the crisis-free energy market in the regions of Russia, Fig. 2 defines the regression

Table 1 Statistics on the volume and financial efficiency of energy services, as well as the level of digitalization in the top 10 regions of Russia in economic security in 2021

Region	*Volume of energy products shipped, million rubles* *E*	*Return on Energy Assets, %* *ra*	*Profitability of energy services provided, %* *rs*	*Digitalization level, points 1–100* *dg*
Khanty-Mansi Autonomous Region – Ugra	231,027	7.4	12.5	69.94
Moscow Region	276,445	5.3	8.3	67.60
Republic of Tatarstan	148,124	4.6	4.1	70.01
Yamal-Nenets Autonomous Region	56,404	5.2	−1.1	68.03
Sverdlovsk Region	255,390	−4.0	6.0	54.88
Krasnodar Territory	117,414	3.8	5.3	54.37
Leningrad Region	177,691	6.6	8.7	64.34
Tyumen Region	344,384	6.4	10.9	67.42
Samara Region	126,851	2.4	7.6	61.01
Krasnoyarsk Territory	176,653	7.9	32.2	57.81

Source Compiled by the authors on the basis of materials Institute of Scientific Communications (2021), Federal State Statistics Service (2021)

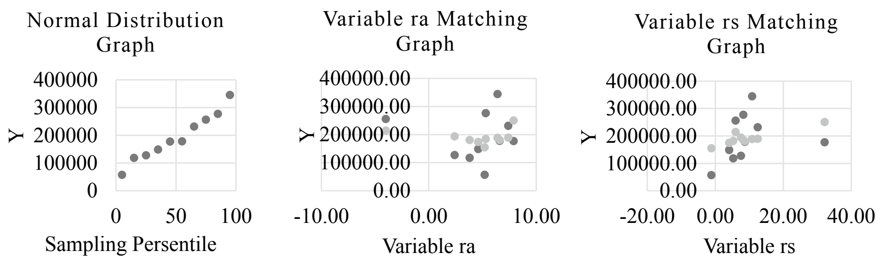

Fig. 2 Regression dependence of the volume of energy products shipped on the profitability of assets and services rendered in the energy sector (*Source* Calculated and built by the authors)

dependence of the volume of energy products shipped on the profitability of assets and services provided in the energy sector.

According to the materials from Fig. 2, the regression equation is obtained: E = 179,206.2-4,006.91ra+3,182.574rs. Therefore, only the profitability of energy services provided positively affects the volume of their supply

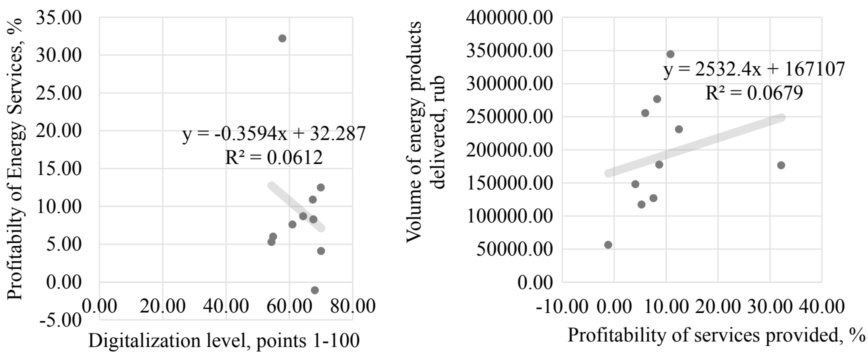

Fig. 3 Regression dependence of the volume of energy products shipped on profitability and services rendered in the energy sector and its dependence on the level of digitalization (*Source* Calculated and built by the authors)

(increasing it) in the regions of Russia. The regression dependence of the volume of energy products shipped on the profitability and services provided in the energy sector and its dependence on the level of digitalization is revealed in Fig. 3.

According to Fig. 3, with an increase in the profitability of energy services provided by 1%, the volume of energy products shipped increases by 2532.4 million rubles. But increasing the level of digitalization by 1 point reduces the profitability of energy services provided by 0.3594%. Consequently, the digitalization of energy in Russia increases the risks of energy crises and threatens the economic security of the regions. In order to solve this problem, a financial strategy for the energy crisis-management of the regional economy in the 4.0 industry in the interests of security has been developed (Fig. 4).

According to Fig. 4, in the first stage, preparatory digitalization is carried out, involving state co-financing of digitalization of energy in order to maintain the profitability of the energy sector. In parallel with this, R&D in the energy sector is carried out. At the second stage, the main digitalization is carried out—there is a transition to higher digital technologies (more cost-effective) to increase the profitability of energy companies. The third stage is related to supporting digitalization. It involves the periodic introduction of advanced technologies in the energy sector for the stable profitability of energy services.

5 Conclusion

Therefore, it is proved that in the conditions of industry 4.0, the threat of energy crises that threaten the economic security of the regions of Russia is aggravated (the hypothesis is confirmed). The decline in profitability of energy

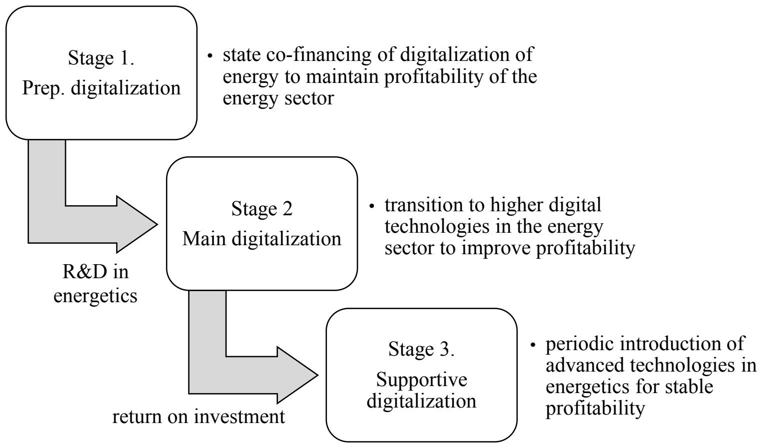

Fig. 4 Financial strategy of energy crisis-management of regional economy in industry 4.0 for security (*Source* Developed and compiled by the authors)

services as they digitalize can be due to both the long-term return on investment in digital innovations and the low financial efficiency of the introduced digital technologies.

The developed financial strategy of the energy crisis-management of the regional economy in the conditions of industry 4.0 in the interests of security allows to overcome these shortcomings of digitalization of energy in Russia. The strategy allows you to balance and simultaneously implement both current areas of energy development: the transition to energy 4.0 and ensuring the sustainability of energy in the aspect of lack of energy supply in the regional economy.

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Prospects to Combat Climate Change in the Economy of the Future in the Context of Industry 4.0 at the Territorial Level

Brazil's Green Energy: Today and Tomorrow

Eugene M. Khartukov and Ellen E. Starostina

1 Introduction

Modern Brazil is extremely committed to "green", ecologically clean energy—the use of renewable energy sources (RES) in the country now ac-counts for over 80% of all primary energy (for comparison: in Europe—less than 45%). Hydroelectric power plants, which are the main energy source in the country, account for 70% of Brazil's electricity generation. Brazil is a major player in the global energy market: it ranks second in biofuel production and hydropower generation; 8th place in terms of wind power plants capacity and 9th place in hydrocarbon production The Brazilian electric power market relies even more on renewable energy sources (82%) than the country's energy sector as a whole [Ethanol fuel, 2020].

2 Methodology

In this research paper, the authors use methods of comparative and systematic analyses.

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3 Results

Interest in ethanol temporarily increased in the years of the WWII, when oil and other hydrocarbon resources were far from abundant. In the 1970s, interest in this material as a transport fuel revived as oil embargoes were imposed, oil prices rose and reliance on imported oil grew. Since then the use and production of ethanol are encouraged by tax incentives and environmental regulations requiring cleaner combustion of fuels. Also, in 2005, the US Congress passed the Renewable Fuel Standard (RFS), which set minimum requirements for the consumption of renewable fuels. In 2007, it was determined that by 2022, the RFS renewable fuel targets in the United States would increase to 36 billion gallons (over 136 billion liters) a year. (FYI: In 2017, the USA consumed about 14 billion gallons (almost 53 billion liters) of fuel ethanol).

Biofuels. In the fuel balance of Brazil, the ethanol production exceeds 20%. Since 2004, the country has been producing ethanol from its own sugar cane. 3 Brazil is the world's second largest (after the US) producer of ethanol fuel. In 2017, Brazil and the United States together accounted for 85% of global production. Brazil produced 26.72 billion liters (7.06 billion gallons), which is more than 26% of the total ethanol production used as a fuel in the world in 2017 (in FY 2005 it was 16.6 billion liters), of which 2 billion liters were exported for the amount of USD 600 million).

Brazil is a truly unique country in the sense that it manages to satisfy almost 50% of its domestic fuel consumption with ethanol. No other country in the world can boast of two thirds of the country's vehicles, which are record indicators for the use of green fuels. Currently, 70% of Brazilian cars can "drink" alcohol instead of gasoline. The early 1970s were the time of "Brazilian economic miracle."

However, the miracle has faced big problems. First, in October 1973, Arab oil-exporting countries have temporatively stopped their petroleum supplies to nations, which supported Israel in the so-called Yom Kippur War. Eventually, world oil prices quadrupled. Next, with regard to world sugar prices. They rose sharply from the beginning of the 60s, then interrupted their growth and declined strongly in 1974. Ernesto Gisel, who was the head of state during this period, made a dramatic decision that turned out to be fateful. He adopted a program of gradual replacement of gasoline with ethyl alcohol, which caused many problems for sugar producers. Since the mid-1970s, legislation has been passed obliging oil sellers to use at least 20% ethanol as additives. The government has spurred this program by providing loans at lower rates and guarantees to firms with plans to build ethanol plants. State institutions were charged with buying alcohol at more expensive prices. At the same time, gasoline taxes have been increased to ensure that ethanol is more profitable.

The results turned out to be fantastic: in only four years by 1980, ethanol production in Brazil increased sixfold (!).

The costs of ethanol production and the question of its profitability depend on many factors: the agricultural crop from which the alcohol is obtained, the size of the average worker's salary and the technology for processing raw materials. At one time in the United States, they also tried to transfer cars to ethanol, but they faced insurmountable difficulties. Climatic conditions do not allow the cultivation of sugarcane in America—a less efficient corn was used instead, and the situation on the labor market does not allow paying an American worker a Brazilian wage. Therefore, the US idea had to be abandoned. The beginning of the economic boom in Brazil had happened in 1973–1974, when the country had to urgently solve two problems at once: a threefold rise in oil prices and extensive own consumption of export item No.1—sugar. As it was said above, in this situation, the then-head of state Ernesto Gisel makes a fateful decision to start a state-run project to convert Brazilian cars to alcohol. At the same time, the problem of stimulating sugar suppliers who were in crisis was being solved. Since 1975, by virtue of the law, the obligatorily gas station dilutes gasoline with ethanol in a proportion of at least 80% to 20%. Companies wishing to build alcohol processing plants received loans at minimal interest rates. By the early 1980s, all of the leading carmakers manufacturing in or exporting cars to Brazil should have started making cars capable to use alcohol. Citizens who wished to reequip their gasoline cars for a new type of fuel received benefits. All of these events developed jointly in a large-scale—advertising campaign, in which representatives of Brazil: senior management, sports stars, and ordinary citizens preferred alcohol cars. (Even the Brazilian famous football player Pele started to drive his cabriolet on ethanol). In 1985, Brazil celebrated a new victory—according to statistics, half of the country's car fleet was driven by ethanol.

Unfortunately, a severe inflation had started in Brazil in 1985, and the Brazilian economy began a protracted crisis that would last until 1995. The 5 abrupt drop in prices also shows that gasoline is becoming cheaper than ethanol. At the same time sugar prices began to rise. The crisis forced the country's government to cut funding for "alcohol" projects, ethanol production volumes sharply reduced.

The introduction of ethanol in Brazil helped create a new export market, with supplies to the United States, Japan and Western Europe. The world is closely watching the "ethanol experiment" and a number of countries in Europe and Asia are promoting government programs to switch to this type of fuel. The use of ethanol as a base fuel brought with it a number of problems, but the effectiveness of this project as a national project was high. As a result, the country got rid of oil dependence, significantly increased employment, and at that time practically solved the problem of using it as an alternative renewable fuel in Brazil. But since the mid-1980s, new problems have emerged: due to the fall in oil prices, gasoline has become cheaper than ethanol. Subsequently, the trend of rising sugar prices intensified, due to which the production of ethanol alcohol began to decline. As the companies continued to manufacture only ethanol-powered machines, this began to affect product results. Since during this period, all new cars sold in the country were completely focused on ethanol, a crisis erupted in the early 90s, since the production of ethanol in Brazil became less than the economy required. Thus, the country began to export ethanol and use it as a mixture with methyl alcohol (methanol). Car manufacturers gradually switched to assembling gasoline vehicles, eventually only rental cars and taxis continued to use ethylene fuel.

Nevertheless, ethanol was not completely abandoned—by the end of the 1980s, a lion's share of cars sold in the country were able to run on alcohol. But since the fuel for these cars was sorely lacking, in the period from 1990 to 1995, automakers again began to produce cars using gasolines. However, the "80–20" rule established by the government, according to which every gas station in the country must add at least 20% ethanol to gasoline, continued to apply to all automobile products manufactured in Brazil. Perhaps it was this measure that saved the "alcohol" program from curtailing and marked the beginning of a new round of Brazilian automotive history. The end of the 1990s was marked by the emergence of new types of engines capable of consuming both conventional gasoline and "flexible fuel"—a mixture of ethanol and gasoline in a ratio of 85% to 15%. The benefits for environmentally friendly engines are coming into force again, making ethanol cars about 2% cheaper than gasoline counterparts. A large role in the introduction of ethanol was played by the traditionally low cost of alcohol production in Brazil: about \$0.8 per gallon, while it costs \$1–1.30 to produce a gallon of ethanol from corn in the USA. The minimum prices for alcohol are part of the country's state policy: the customs duty on exported ethanol is 30%.

By 2006, the results of the widespread use of alcohol in Brazil were as follows: 4.3 million vehicles run entirely on alcohol, the remaining 17 million use a mixture of alcohol and gasoline as fuel. 5 out of 6 Brazilian gas stations sell pure ethanol. The switch to a new type of fuel has given jobs to nearly 10 million 27 29 3 6 Brazilians; over the past 30 years, thanks to ethanol, the country has significantly reduced its dependence on oil (in fact, ethanol has replaced Brazil's 1.5 billion barrels of oil reserves).

Regarding the Brazilian "ethanol miracle", it is noteworthy that although the introduction of ethanol as the main fuel has been associated with many problems, the results of the national project were surely positive. Brazil has managed to create a sizeable job market, got rid of the oil "addiction", reduced the burden on the environment, and most importantly—in practice, has proved the reality of the transition to a renewable fuel within the entire country.

However, the government was not inferior here in one thing—at least 20% of ethanol had to be added to the gasoline sold at gas stations. The Brazilian experiment found its "second wind" only at the beginning of this millennium. The largescale coming of biofuels to the Brazilian energy sector was marked by the following major measures and events:

- In mid-November 1975, the Brazilian government adopts the Program to stimulate the production of ethanol in the country Pró-Álcool, formalized by Decree No. 76 593 and envisioned two stages (1975–1979 and 1979–1989);
- In 1979 the Brazilian Fiat 147 becomes the first modern car launched on the market and capable to run on pure ethanol (E100);
- the second phase of the Pró-Álcool program began in 1979, when the Brazilian government has signed agreements with a number of the leading car-making companies (the Italian Fiat, the Japanese Toyota, the German Mercedes-Benz, the U.S. General Motors and, finally, the German Volkswagen) requiring that they collect in Brazil only 100%-alcohol car models. In addition, tax incentives were introduced for car owners, who agreed to convert their cars from gasoline to alcohol;
- late 1985: between 1979 and 1985, the country's ethanol production tripled. By this time, ethanol provided half of the needs of Brazil's automotive fuel;
- In 1990, production of pure ethanol vehicles in Brazil fell to 11% of total vehicle production as consumers lost confidence in the reliability of ethanol fuel supplies and began selling or converting their vehicles back to use gasoline;
- In October 1993: Federal Law No. 8 723/93 was passed establishing a mandatory blend of 22% anhydrous ethanol (E22) for all gasoline sold in the country. In fact, this was the first time that the Brazilian authorities declared environmental rather than economic goals to increase the use of ethanol. In 1993, 40% of the Brazilian vehicle fleet was operated on pure ethanol, and 60% on an alcohol-gasoline mixture;
- At the end of October 2002, Brazil presented its new diesel program (Prodiesel) for the production and use of biodiesel in Brazil. The program was designed for pure petroleum diesel as well as blended diesel with vegetable oils, in particular soybeans. Also Brazilian the government has passed a law that provided for the use of biodiesel in a share of 2% by the end of 2007 (about 800 million liters per year) and in a proportion of 20% by 2020 (12 billion liters a year);
- In 2003 "flexible (optional) fuel vehicles" (FFVs), which can use a mixture of 85% alcohol and 15% gasoline as well as regular gasoline, appear on Brazilian roads. A number of car companies have agreed with the Brazilian government on tax breaks (the sales tax on FFVs was 14%, and for gasoline models—16%) and began to produce FFVs—a pioneer here was the US Ford, which opened its assembly line in Brazil's north-east, in the city of Bahia, in 2002. These cars have become very popular: if in 2005 they accounted for 53% of total sales in 2006, then in 2006—already 70%;
- In March 2003.
- Volkswagen launched in the Brazilian market the Gol 1.6 Total Flex, the first commercial "flexible" vehicle capable of running on any mixture of

gasoline and ethanol. Chevrolet followed three months later with the Corsa 1.8 Flexpower, using an engine developed by a JV with Fiat under the name of Power-Train.

By 2003, the Brazilian auto industry had developed flexible vehicles that can run on any proportion of gasoline and anhydrous ethanol (up to and including E100). Introduced in 2003, flexible cars have become real best-sellers, clearly dominating the passenger car market with a maximum 94% market share of all light vehicles sold in Brazil in 2013. According to a forecast of the California-based company Ceres, Inc., operating in the Brazilian biofuel market (Energy Crop Co.), the fleet of light-duty FFV (vehicles with flexible fuel choice) will increase from 17.5 million units (53% of the country's total light-vehicle fleet) in 2012 to about 45 million units (76%) in 2022, while a value of gross receipts from the sale of fuel to these cars at the country's gas stations should grow from US$6 billion to US$18 bln [www.sec.gov, 2020]. On December 6, 2004, the Brazilian government launched, on the basis of Federal Decree No. 5,297, a program of the so-called "social fuel label, or seal" (or Selo Combustível Social, *SCS*in Portuguese) to promote the social integration of family farmers from the two poorest regions of Brazil: the North and the Northeast. Castor bean, which grows abundantly in both regions, could become a full-fledged competitor to sugar cane, if not for the fact that castor oil obtained from this oilseed has a very high viscosity—14.1 mm^2/s, which is well above the maximum specified by the Brazilian oil and gas and biofuel agency ANP (6.0 mm^2/s) and is not suitable for the production of fuel ethanol. SCS is also a mechanism that serves to reduce government taxes and allows the Brazilian Development Bank (BNDES) to provide biodiesel producers who purchase feedstock from family farmers with lower interest loans. Although the *SCS* program was conceived to bring about major socioeconomic changes in the northern and northeastern regions (as originally envisioned by the government), despite modest progress, many Brazilians see it as a failure.

The reasons ranged from high logistic and logging costs to inefficient use of agricultural machinery, artificial irrigation and fertilization, and lack of access to finance due to bureaucratic delays. Therefore, this program is currently being revised to correct errors made by ANP (The Brazilian National Agency of Petroleum, Natural Gas and Biofuels).

On January 13, 2005, Federal Law No. 11 097 was adopted, through which the Brazilian government officially introduced the National Program for the Production and Use of Biodiesel (Programa Nacional de Produção e Uso de Biodiesel, or *PNPB* for short), one of the main objectives of the *PNPB*, in addition to promoting social inclusion family farmers, primarily from the northern and northeastern regions of Brazil, there was also a decrease in imports of mineral diesel fuel, which should have a positive effect on Brazil's trade balance. In addition, the program also provided for the establishment of a minimum mixing percentage of biodiesel with petroleum diesel fuel. Initially (from 2005 to 2007) the proposed mixing percentage (2%) was optional, and then (from January 2008) it was mandatory. Production percentages between 2005 and 2010 were (on average) very high compared to 2011–2017.

- Although 2014 was the year in which the mix changed twice, the percentage increase was relatively low: only 17%. And since then, the percentage has declined and even turned negative in 2016, the year when biodiesel production declined for the first time since the *PNPB* program was established in 2005. Since the beginning of the *PNPB* program, soybeans have become the main and dominant feedstock for biodiesel production, accounting for an average of 75%, and beef tallow (15% on average). Other feedstocks such as cotton seed, used vegetable oil and other fats accounted for the remaining 10% in total. This clear dominance of both the raw materials has prompted the Brazilian government to create echanisms to encourage the use of alternative raw materials. From this year to 2012, the country became one of the world's largest producers of biodiesel.
- As of July 1, 2007, a fuel blend of 25% anhydrous ethanol and 75% gasoline (E25) becomes mandatory in Brazil;
- November 2009: Launch of the first urban bus in São Paulo, running almost entirely on pure ethanol (E95);
- In April 2011, the lower limit for compulsory use of ethanol in Brazil was legislatively reduced to 18% due to recurring domestic shortages of ethanol and high prices for it, which increased sharply between harvest seasons of sugar cane;
- End of 2011: the share of light vehicles running on ethanol or alcohol-gasoline mixtures exceeded 83% of the total number of the Brazilian light vehicle fleet;
- 2013: the annual production of FFV-class passenger cars reached almost 3 million units, and their share in the total annual production of passenger cars in Brazil was 83% (Fig. 1) (in 2017, according to the São Paulo-based National Association of automakers ANFAVEA, the production of such cars in the country amounted to over 2.13 million units, and their share in the production of passenger cars of all models is 81.9%).

- In early September 2014, the Brazilian federal government extended a program known as Reintegra, which allows manufacturers to receive a tax credit of 0.3% of their export earnings in 2014 and 3% from 2015. all Brazilian-made products, observers see it primarily as a measure to stimulate ethanol production;
- On September 24, 2014, the federal government adopted Law No. 13033, which provides for the possible mixing of biodiesel with petroleum diesel fuel in the following proportions: 6% (B6) from July 1,

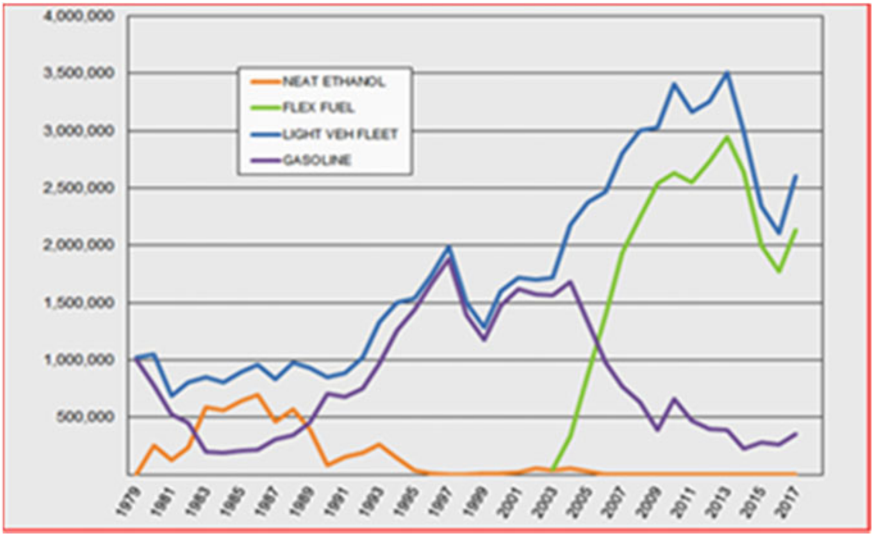

Fig. 1 Annual production in Brazil in 1979–2017 of passenger (LightDuty) cars using various fuels, in units (*Source* https://howlingpixel.com/i-en/UNICA, Brazil [Accessed: 10 October 2020])

2014 and 7% (B7) from November 1 the same year. This law allowed the use of biodiesel in diesel fuel in quantities exceeding the mandatory share for public transport (rail and inland waterways), equipment or vehicles for mining and electricity generation, tractors and other vehicles intended for towing agricultural machinery or for performing agricultural work;

- In September 2015, the Ministry of Development, Industry and Trade (MDIC), together with the Brazilian Chamber of Commerce (CAMEX), extended the zero import tariff on ethanol until the end of 2021;
- 2015: Brazilian ethanol production was 27.552 billion liters, up from 25.585 billion liters in 2014 (+7.7%);
- On March 23, 2016, the Brazilian President Dilma Vana Rousseff signed Federal Law No. 13 263/2016, which raised the bar for the possible addition of biodiesel to diesel fuel used in the country from the existing 7% (B7) to 8% (B8) since March 2017, 9% (B9) from 2 to 13 March 2018 and 10% (B10) from March 2019 (see above). Totally, federal loans valuing some 2 billion reais (about US$ 555 mln) were to be provided. The interest rate on bank loans was not specified but the payments should have been made within 270 days after the grant;
- 2016: Brazilian ethanol production was 28.022 billion liters, up from 27.552 billion liters in 2015 (+1.7%);
- In August 2017, the Ministry of Development, Industry and Trade (MDIC) and the Brazilian Chamber of Commerce (CAMEX) introduced an annual tariff quota (TRQ) of 600 million liters of benchmark imports,

effective from the beginning of September 2017. Ethanol imported into Brazil, in excess of this quota, was subject to the payment of an import duty in the amount of 20% of the total external tariff for the countries participating in the regional economic grouping of Mercosul;

- The TRQ was to be reviewed by the CAMEX Chamber on a quarterly basis, and 150 million liters of the imported standard would be exempted from import duties every quarter. The TRQ revision should take place 24 months after the introduction of the quota, that is, at the beginning of September 2019;
- On December 26, 2017, the Brazilian government transformed the National Biofuel Policy (or Política Nacional de Biocombustíveis or RenovaBio), designed to radically expand the production and use of all types of biofuels in the country (i.e., primarily biodiesel, bio methane and ethanol), as well as to increase the energy the security of the whole country and therefore create more jobs and incomes, enhance the social inclusion of families of farmers, and help Brazil fulfill its international commitments to reduce greenhouse gas emissions in the relevant national program and in Federal Law No. 13576, which provided for an increase in the annual consumption of 14 ethanol in Brazil from 26.7 billion liters in 2018 to 47.1 billion liters by 2028. The program entered into force in the next two years and was designed for a decade. By 2030, it was estimated that national ethanol production would grow from 43 billion to 54 bln liters in addition to the level of production of almost 28 million liters in 2017. The RenovaBio was also supposed to improve Brazil's foreign trade balance by reducing the country's dependence on corn ethanol imports from the United States. This program also set the rules for the marketing of biofuels in the country under the banner of environmental sustainability and was supposed to help increase the reliability and predictability of the national biofuel supply. In this way, the Renovabionot only helped the environment, but also created better market conditions for domestic and foreign private investment;
- In March 2018, the Brazilian federal government increased the rate of possible use of biodiesel (see above) from 8% (B8) to 10% (B10) one year ahead of schedule;
- In mid-July 2018, Brazil's Ministry of Agriculture, Livestock and Supply (MAPA) announced a plan to promote the country's agriculture and livestock development in 2018–2019 with funding totaling 194.3 billion braz. reais (more than US$ 50 billion). Those significant funds come in the form of credit lines from the National Bank for Social and Economic Development (BNDES) and were intended to support national agricultural and livestock programs. The amount of credit lines allocated to the ethanol industry (as part of the BNDESPASS support—see above) were not disclosed, but this should have been a fairly substantial sum;
- 2017: Brazilian ethanol production was 27.778 bln l up from 28.022 bln l in 2016 (i.e. +0.9%) (ANP data);

- 2018: US Department of Agricultural (USDA) estimated that ethanol exports from Brazil at 1.12 billion liters (18% less than in 2017), and imports at about 2 billion liters, or 255 million l more than in 2017, however, ethanol imports to Brazil were expected to decline in 2019 by about 30%;
- In early July 2019, the Brazilian Energy Policy Council (CNPE) passed a resolution allowing sugar cane refineries to sell ethanol directly to gas stations (by-passing intermediaries). There are no longer pure gasoline-powered passenger cars in Brazil. To provide fuel for the country's car fleet, the production of ethanol produced from sugarcane was increased to 16 billion liters or more per year. Brazil buys a certain amount of ethanol (especially during periods of drought) from other countries (primarily from the United States). By the mid-10s of this millennium, the ethanol industry in Brazil was fully formed and acquired the following form (Figs. 2 and 3).

During the last 2019-year Brazil produced over 8.6 bln US gallons of fuel ethanol or nearly 30% of the world's total of 29.1 bln US gal (Fig. 4). Petrobras, the Brazilian national oil company, exported a total of over 510 mln gal of ethanol—mainly to the USA, South Korea, Japan and the Netherlands, Venezuela, Colombia, Paraguay and Uruguay, Nigeria and Angola, the PRC and India as well as (albeit in much smaller volumes) to France and even to the West African Cote D 'Yvoire (formerly Ivory Coast).

Currently, there are 41 biodiesel plants in Brazil, authorized by the National Agency for Oil, Gas and Biofuels or ANP (in 2008 there were only 23). Brazil is a unique country that manages to meet almost 50% of its domestic fuel demand with ethanol. Two-thirds of the country's vehicles are capable of driving alcohol; no other country can boast of such record indicators of the use of environmentally friendly fuel. Brazil became addicted to ethyl alcohol in

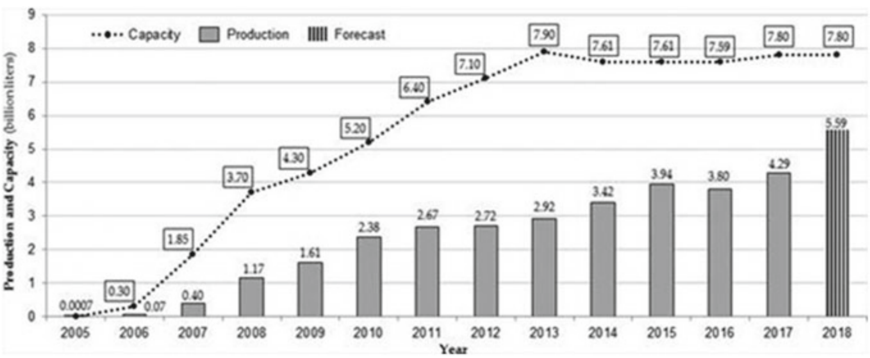

Fig. 2 Dynamics of production and capacity of production of ethanol, in billion US gal (*Source* https://www.unica.com.br/iniciativas [Accessed: 11 October 2020])

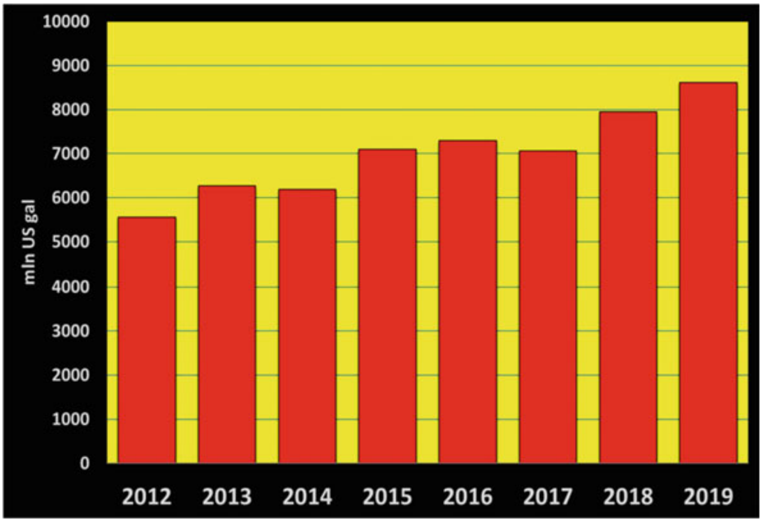

Fig. 3 Annual ethanol production in Brazil 2012–2019, in mln US gal (*Source* Based on https://www.statista.com/statistics/968331/ethanol-production-brazil and https://en.wikipedia.org/wiki/Ethanol_fuel_in_Brazil#Economic_and_production_indicators [Accessed: 11 October 2020])

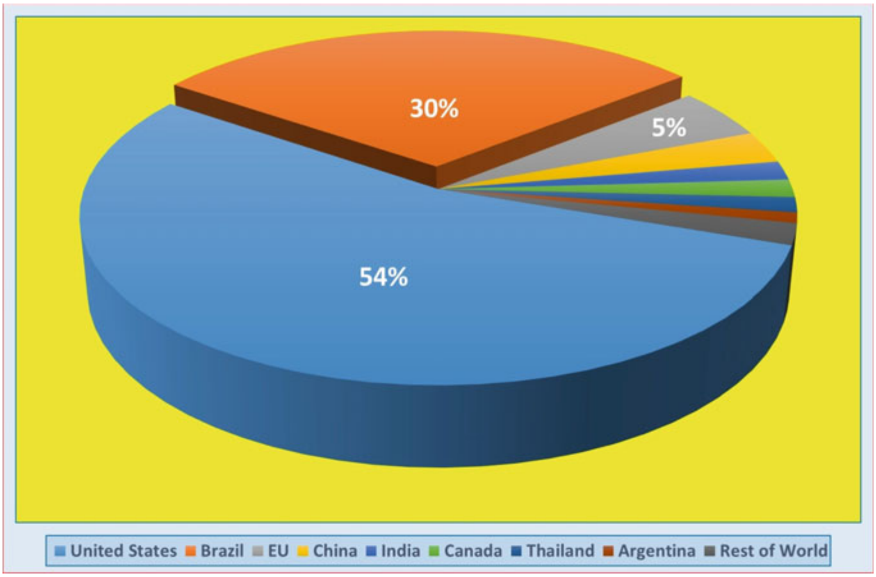

Fig. 4 Distribution of global ethanol production in 2019 by country and grouping, in %% (*Source* Based on https://www.statista.com/statistics/281606/ethanolproduction-in-selected-countries https://www.statista.com/statistics/281606/ethanol-production-in-selected-countries [Accessed: 11 October2020])

the 70s during the next rise in oil prices. Since then, a third of all cars in Brazil have been driven by ethanol. Now Brazil has very strong global positions in the production and the use of fuel ethanol (Figs. 5 and 6).

It is interesting to note that Brazilian motorists no longer tire themselves with complex calculations of the optimal composition of the used alcohol-gasoline mixture—a fueling station's computer will quickly calculate its most economical composition, even taking into account which road you drive—a gentle city road or mountain one, which requires more power from the engine, provided by the use of alcohol…

Since April 2011, the minimum percentage of ethanol blended with gasoline might legally vary in Brazil from 18 to 25%—in accordance with the Decree No. 532 of April 2011. In 2011, the national minimum requirement for ethanol was temporarily lowered from E25 to E20 (see above). The 25% requirement was restored only in June 2012, and in 2015 the Brazilian government decided that the ethanol content in the alcohol gasoline mixture should be at least 27%. Brazil generally meets the consumption standards for 5% biodiesel in diesel and 20–25% bioethanol in gasoline. The actual consumption of bioethanol in Brazil is higher than standard because, in addition to being mixed with gasoline, some pure ethyl alcohol is consumed by flex-fuel vehicles and ethanol-only ones. According to the Russian website ForexAW,

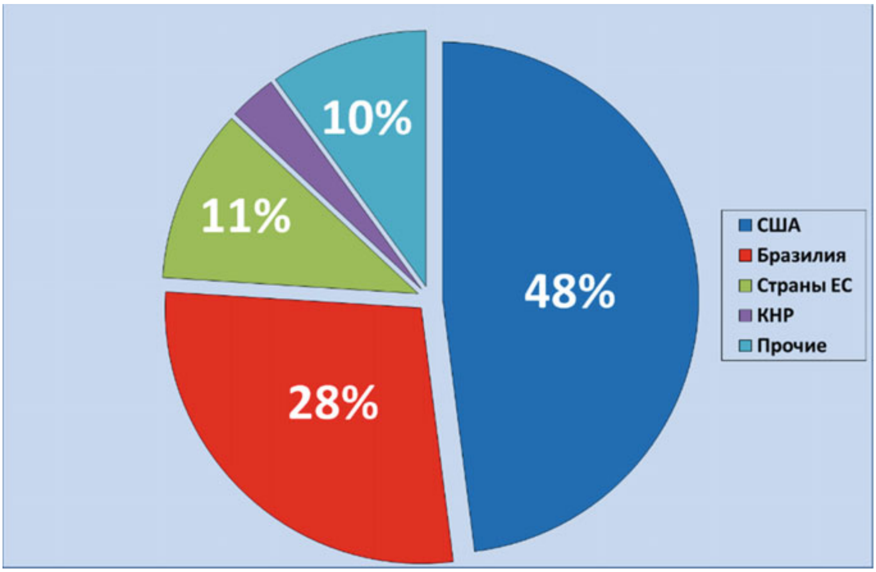

Fig. 5 Distribution of global consumption of fuel ethanol in 2018 by country and country grouping, in %% (*Source* Based on http://www.zanran.com/q/Regional_distribution_of_world_ethanol_production_and_use and https://www.indexmundi.com/energy/?product=ethanol&graph=consumption&display=rank countries [Accessed: 11 October 2020])

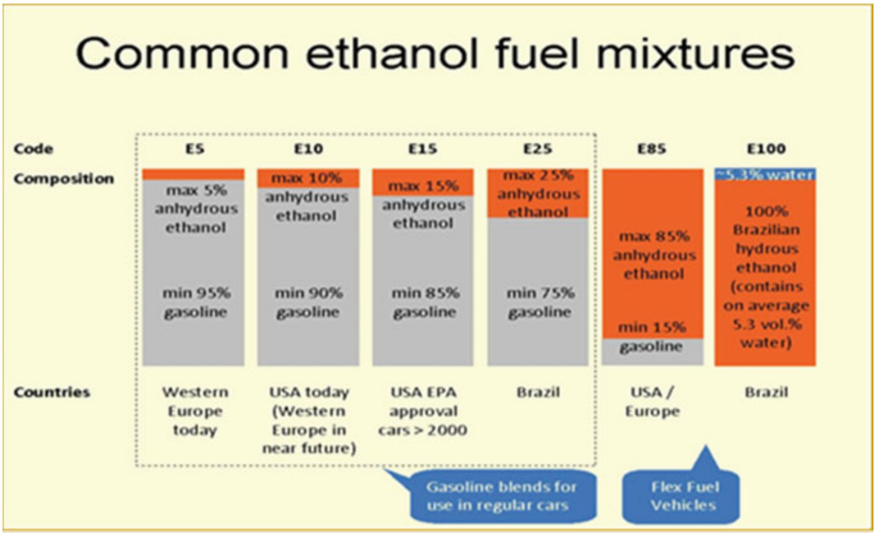

Fig. 6 Use of ethanol-gasoline blends in Brazil and the world (*Source* https://en.wikipedia.org/wiki/Common_ethanol_fuel_mixtures [Accessed: 10 October 2020])

the long-term forecast of world biofuel production up to 2050 (according to the international agency for renewable energy sources IRENA) looks as follows (Fig. 7).

At the same time, according to Bloomberg, ethanol production in Brazil should remain at about the same level—2–3 billion liters a year. The use

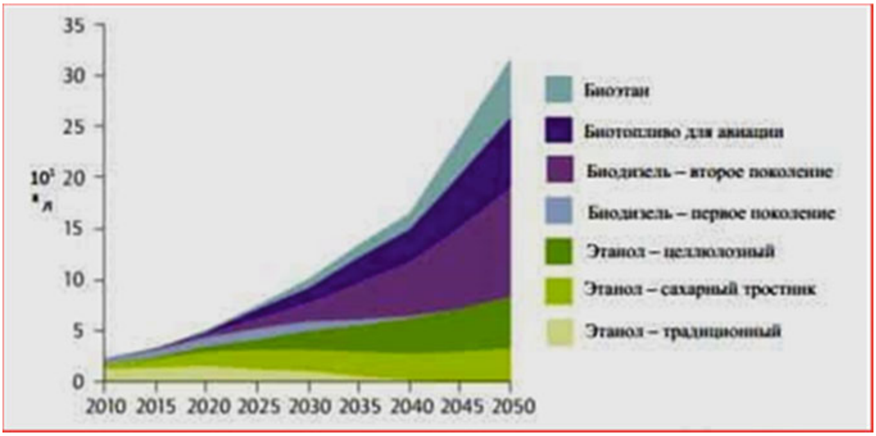

Fig. 7 World production of biofuels in 2010–2050 by feed or application, in billion liters (*Source* Based on https://www.irena.org/media/Files/IRENA/Agency/Publication/IRENA_REmap_2050_Biomass_paper [Accessed: 10 October 2020])

of biofuels in the transport sector is an important way to reduce emissions of harmful substances into the atmosphere while increasing its efficiency. An important role in the use of this type of fuel will be played by the use of alternative low-carbon fuels for aircraft, ships and other heavy vehicles. Already today, liquid biofuels provide about 3% of all fuel for transport, but should reach a significant share in some countries, most actively developing this sector. For example, in Brazil, already now, the share of ethanol use in the transportation sector is over 20%, while in the USA and the EU—just over 4%. Many reed plants in Brazil, the world's largest sugar producer, can easily switch between ethanol and sweetener production, and this can distract cane processors from producing sugar. Ethanol competes directly with gasoline at Brazilian gas stations, thanks to the large number of FFVs in the country's fleet.

4 Conclusion

Due to quite long lead times in creating energy infrastructure, Brazil will surely remain the world's greenest energy economy in the years to come.

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Regional Studies Work as a Source of Fostering Environmental Culture in Undergraduate Students

Tatiana I. Alekseeva and Larisa A. Sergeeva

1 Introduction

The relevance of the problem considered in this article is determined by the fact that in the modernsociety, the ecological imbalance between nature and man is becoming more and more aggravated.

This is why there is a significant need to address the concept of "environmental culture" on various levels, including the level of higher education of bachelor students as the future primary school teachers.

In matters of fostering the bachelor students' environmental culture, the problem of transforming the student's ecological consciousness and developing his or her environmental awareness is brought to the fore. A special role in solving these problems belongs to the content materials of regional studies, namely, regional geography studies.

At this stage, the following questions arise: "What is the set of forms of regional studies work organization with the undergraduate students that contributes to fostering their environmental culture?", "What are the ways to implement this set of forms in the educational process of the University?".

Thus, the goal of this article is a theoretical description of a set of forms of organizing regional studies work with undergraduate students, aimed at creating and developing the environmental culture in future primary school teachers and empirical grasp on the pedagogical experience of implementing each of the identified forms in the educational process of the University.

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The research methods are: theoretical analysis of literary sources and pedagogical experiment.

The research was conducted on the basis of the Educational Technologies and Design Department (now the Institute of Education and Social Sciences) of Pskov State University and the 1st-year students majoring in “Pedagogical education”, “Primary education” profile of training.

2 Methodology

The methodological basis of this study is based on the following theoretical propositions:

- the methodological basis for the environmental culture formation among undergraduate students is the activity-based and systemic approaches;
- the systemic approach focuses on the category of “environmental culture” as an integral system consisting of a set of interrelated structural components, namely, environmental culture is understood as an integrative personal entity, the features of which determine its leading specific characteristics: in the cognitive sphere—the awareness of environmental culture as a positive value; in the emotional sphere—moral and aesthetic feelings and experiences generated by communication with nature; in the volitional sphere—implementation of environmental activities, creative self-realization in solving environmental problems (Tregubova, 2015);
- the components of environmental culture include: cognitive, emotional and aesthetic, and activity-oriented (Filinov, 2004);
- environmental culture is considered to be the result of students’ activities, which show their attitude to nature. According to academician V. D. Davydov’s point of view, “genuine activity is always associated with the transformation of reality”, and the transformative nature of the activity gives the subject the opportunity to go beyond a specific situation (Davydov, 1986);
- tourist-oriented and regional studies activities are an important means of fostering environmental culture (Polyanskaya, 2010; Samarina, 2004);

The comprehensive analysis of literary sources (Tregubova, 2015; Polyanskaya, 2010; Filinov, 2004) allowed us to draw a conclusion about the plurality of opinions in scientific research about the essence of the concept of “environmental culture”.

It is known that “the form is a way of existence and expression of the content”. In other words, it is possible to speak about the significant influence of the regional studies work form on the process of fostering environmental culture among undergraduate students only if the form assists in revealing the internal organization and structural components of the environmental culture in students’ educational activity (Ilyichev, 1983).

As the first organizational form of regional studies work, we used educational WebQuests.

Characterization of the first organizational form is possible if based on the following theoretical positions:

- fostering the environmental culture in undergraduate students through conducting educational WebQuests should be considered as an integration of methodological strategies for organizing research and project-oriented regional studies activities of students using the Internet (Sergeeva, 2016);
- organizing and conducting educational WebQuests based on the regional studies content material can be carried out as an individual or group project, the main task of which is to solve a problematic environmental issue (Kryukova, 2017);
- the formation of the environmental culture components in the undergraduate students is carried out in the educational WebQuest in the course of a role-playing game (Khanturova, 2017);

It is known that a WebQuest is a scenario for organizing project activities of students on a classroom topic using Internet resources (Andreeva, 2014). Researchers identify the following elements of a WebQuest: introduction; description of the topic, goals and tasks of the quest; distribution of roles among students; defining the presentation form of the final result; description of the stages of work and the Internet resources; description of criteria and parameters for evaluating the work performed by students (Sergeeva, 2017).

Research and project-oriented regional studies activities implying the use of the Internet contribute to forming and developing a system of practical skills, foster the creative nature of the student's participation in solving an environmental problem (i.e. provide the establishment of an activity-oriented component of environmental culture) in undergraduate students.

To implement pedagogical management of the process of the environmental culture components formation in undergraduate students through educational WebQuests, the undergraduate students were offered group projects that involve searching activities involving modern web technologies.

As the second organizational form of setting up regional studies work, the "Regional Studies Puzzles" geo-game project should be highlighted. The game consists of the following stages (Ostapenko & Sergeeva, 2019).

The first stage of the "Regional Studies Puzzles" geo-game is the "organizational" stage. There are two possible forms of this stage. In the first case, the undergraduate students discover places of historical and geographical heritage in Pskov and the region on their own using Internet sources; they formulate a problematic question about an event or a person related to this place; develop routes to the discovered destination points and issue route sheets with a QR code. The second form of this stage is the development of the route sheets by the teacher.

The implementation of this stage activates the formation of the cognitive component of environmental culture in students, since the system of environmental knowledge, the estimation of a particular environmental problem is formed in students through the geographical features of the area where the participants of the project live.

At the second, tourist-oriented stage of the geo-game, the formation of the emotional, aesthetic and activity-oriented components of the environmental culture of undergraduate students is based on the team's activities along the travel route, searching for the chosen objects and taking pictures of them. Academician D. S. Likhachev wrote: "If a person does not like old streets, old houses that were 'the participants' of his youth, witnesses of historical and revolutionary events, then he does not have the love for his city. If a person is indifferent to the monuments of the country's history, he is usually indifferent to his country" (Likhachev, 1983).

The integral formation of the environmental culture components among the undergraduate students was reinforced at the final, projection stage, by searching for answers to additional questions, performing additional tasks; processing the results of the trip, compiling a report on the work with a detailed description of the route objects; presenting and protecting the finished works in the form of a presentation that helps the student to recognize the environmental culture as a positive value.

The third organizational form of regional studies work aimed at creating an environmental culture is the use of the Walt Disney method in working with undergraduate students in the "Regional Studies in Primary School" course.

By the Walt Disney method we understand a pedagogical tool for gradually creating a project from three positions: "the Dreamer", "the Realist", and "the Critic" in the appropriate order (Ryzhenkov, 2001).

The position of "the Dreamer" is to see the forms of project implementation without any conditions, limits, or restrictions. "The Realist" is responsible for analyzing the dreamer's product in terms of its actual implementation. "The Critic" considers the forms of project organization in terms of possible errors, difficulties, and implementation difficulties.

In other words, when developing a project on a particular regional studies topic, it is important to preserve the creative ideas, identify the conditions and ways of their implementation without excessively idealizing the project.

Implementing this organizational form of regional studies work allows a bachelor student to set up and develop the components of environmental culture successfully by creating a situation in which one can analyze, evaluate, and criticize their own thoughts and ideas from three different standpoints.

3 Results

The conducted empirical research included:

- the searching stage, the purpose of which is to develop the tools for the environmental culture formation among the university students majoring in pedagogy;
- the forming stage, the purpose of which is to shape the components of the environmental culture in students during the study of the "Regional Studies Work in Primary School" course.

The research was conducted on the basis of the 1st-year students of the Educational Technologies and Design department (now the Institute of education and Social Sciences) of Pskov State University, who are studying the "Regional Studies Work in Primary School" course.

The study was conducted using such methods as.

- theoretical analysis of scientific and methodological literature in order to identify the components of environmental culture that can be fostered while the students become familiar with the regional studies content during the 1st year of the University study; development of the tools for setting up and developing the students' environmental culture components;
- an experiment aimed at forming the components of students' environmental culture when they study the "Regional Studies Work in Primary School" course;
- assessment center technology for evaluating the formation level of the environmental culture components in students.

The main methodological component of the students' activity during the "Regional Studies Work in Primary School" course was their educational network projects, in particular, on environmental issues. The projects in this training course are related to the development of real and virtual tours of Pskov, almanacs, oral journals of an interdisciplinary nature, lessons and extracurricular activities for younger students. The implementation of such projects shows the practical significance and the possibility of using regional studies content in the environmental education of both university students and their future pupils.

Let us look at an example of a network project offered as a WebQuest "Pskov Botanical Garden".

As a part of the WebQuest, students are invited to look at the culture of Pskov from the perspective of an ecologist, and use the obtained information to develop a non-standard ("Park") lessons that develop the student's emotional and axiological spheres of personality.

The project consists of three stages. At the first stage, students choose their roles and study the available Internet resources.

The roles of the participants.

The archivists work with the archival materials and documents available on the Internet. The result of the work is a brief historical reference about the history of Pskov Botanical Garden.

The regional specialists select the material about the most interesting events, stories and legends related to the Botanical Garden, find photos or videos.

The cartographers mark the objects located in the Botanical Garden in the late XIX—early XX century and now on the map and provide them with their brief description. The result of the work is an interactive map on the project topic.

The photographers create a photo gallery on the topic "Botanical Garden Today".

The biologists study the species of plants in the Botanical Garden.

The ecologists are considering the possibility of organizing a "labor troopers" volunteer squad to clean the territory of the Botanical Garden.

The litterateurs create a sketch in the fantasy (alternative history) style about staying in Pskov (the beginning of the XX century) and visiting the Botanical Garden.

The journalists "interview" the founder of the Botanical Garden.

The creators create a crossword puzzle and a quiz for younger students on the topic "Botanical Garden". The result of this activity is a newspaper.

The guides develop an "ecological path" through the Botanical Garden.

The designers perform the work related to landscape design of the Botanical Garden.

The blogger develops ecologically-oriented content to be distributed over the social networks.

At the second stage, the students' works are exposed to all the participants of the quest for studying and further use and development.

At the third stage the students using the information obtained at the first stage of the project by all the students of the group, develop a Park lesson with the environmental content for younger students, a virtual or real tour of the Botanical Garden for younger students.

In order to introduce students to the parks of Pskov, as well as the natural objects of the region, the "Regional Studies Puzzles" geo-game is recommended.

In order to conduct a game on the topic "Parks of Pskov", a route is created (by the teacher or students) (Twin Cities Square, Kutuzovsky Square (Garden), Square of the Fallen Fighters, Summer Garden, Botanical Garden), questions and tasks are formulated for each point of the route. At certain times, teams go on the route (the entire trip lasts for no longer than two hours). After completing all the tasks of the route list, the game participants return, find historical information about the objects they visited, about people whose lives were connected with the visited places of the city, rationally arrange and manage the found material supporting it with photos taken.

In the framework of the "Regional Studies Work in Primary School" course students become acquainted with the natural and protected objects of each district of the Pskov region through "Regional Studies Puzzles" geo-game: students create a route on the natural sites of the region, formulate questions and tasks for each object, create an interactive map of the protected natural sites of the region.

When developing an eco trip to Izborsk, the Walt Disney method is used. From the standpoint of "the Dreamer", students suggest writing the chronicle and keeping a travel diary during the trip; organizing a "labor troopers" volunteer squad for cleaning the territory, a flash mob on environmental topics; conducting a debate about a healthy lifestyle; organizing classroom research on ecology and regional studies; contests for dinners, tourist songs, forest crafts, tourist newspapers, drawings, creative reports; regional studies quizzes; games in the fresh air; they develop the topic of "Nature in the Camera Lens" and "Ways of Survival in the Wild" creative laboratories. "The Realist" and "the Critic" adjust the project from the standpoint of its real implementation possibilities and difficulties.

The assessment center technology was used to evaluate the formation level of the emotional, aesthetic and activity-oriented components of the environmental culture in students. Analyzing the results of the diagnostics, we can conclude that by actively interacting with the socio-natural environment, the students have learned to perceive the natural environment aesthetically, experience the pleasure of interacting with it; systematize their own knowledge and get new ideas about the place close to which they live; act in the environment in accordance with the environmental norms of behavior; the students formed a positive emotional and value-based attitude to nature. The students showed interest in distributing environmental knowledge in social media through flash mobs and the organization of a network of social groups.

When analyzing the results using the observational method, we have identified the skills that the suggested organizational forms of students' work had the greatest impact on: research skills (generating ideas, choosing the best solution); social interaction skills; evaluation skills; information skills (searching for the necessary information, evaluating the credibility of the information found); presentation skills (preparing a speech and the necessary demonstration materials, answering questions); management skills (planning the activities, timing and resources; distributing the responsibilities while performing a collective task; choosing roles).

4 Conclusion/recommendations

Conducting theoretical analysis of scientific literature allowed us to identify the following organizational forms of work within the geographic regional studies with students (bachelors), contributing to the formation of the cognitive, emotional, aesthetic, and activity-oriented components of their environmental culture: educational WebQuests, geo-game "Regional Studies Puzzles" project, W. Disney method to accompany the "Regional Studies Work in Primary School" course.

The first organizational form—an educational WebQuest—aims the undergraduate students at participating in group projects involving modern web technologies during practical classes within the "Regional Studies Work in Primary School" course.

The second organizational form—the "Regional Studies Puzzles" geo-game project—is based on organizational, tourist-oriented, and projection stages that bring students closer to recognizing environmental culture as a positive value. To implement the second organizational form of regional studies work, it is necessary to develop a route, its passage and registration of the obtained results. This contributes to forming and developing the cognitive, emotional, aesthetic, and activity-oriented components of the environmental culture among undergraduate students.

The implementation of the third organizational form allows the bachelor student to form an environmental culture by creating a situation in which one person can analyze, evaluate and criticize their own thoughts and ideas from three different standpoints.

The practical significance of these organizational forms of regional studies work is that they can be used as a pedagogical tool for the formation of structural components of environmental culture among undergraduate students in the educational environment of the university.

The conducted empirical research at practical classes of the "Regional Studies Work in Primary School" course allows us to draw a conclusion that the work carried out with students contributes to the formation in students—future teachers—of the environmental culture structural components and organizational skills essential for their future profession.

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Competition for Green Projects and Industry 4.0 Projects in Regional Investment Markets: A Security Perspective

Anna A. Skomoroshchenko, Bogdan S. Vasyakin, Sergey E. Afonin, and Maxim A. Afanasiev

1 Introduction

Modern regions have two priorities. The first priority is to improve the business climate and accelerate economic growth to improve the economic situation of the region. The second priority is to protect the environment and improve the quality of life of the population in order to improve the socio-environmental conditions in the region. While the two priorities are consistent with the sustainable development goals of the region, they are seen as contradictory.

The established approach to investment management in the regions of Russia implies a clear distinction and contrasting of private-commercial effects from investments expressed in the form of profitability of regional entrepreneurship and social effects expressed in the form of environmental improvement and considered non-profit, that is, not income-generating enterprises in the region. With the implemented approach, investments contribute

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to the implementation of only some, as a rule, economic goals of sustainable development, which leads to chronic underfunding of measures in the field of the implementation of social and environmental goals of sustainable development in the regions of Russia.

Green and industry 4.0 projects are competing in regional investment markets, driven by a return-to-risk ratio. With a similar level of risk and investment, digital projects tend to provide greater returns on investment and are therefore most attractive to investment. Green projects are inferior to them in terms of profitability and therefore are much less popular.

In this work, it is hypothesized that from the point of view of environmental safety, green projects are more promising than digital ones and therefore should have a greater investment attractiveness in the context of the implementation of sustainable development goals in the regions. The purpose of the research is to develop a new approach that clarifies the investment attractiveness of innovative projects in the region, taking into account a systemic view of the goals of sustainable development with integrated risk management, profitability and environmental safety, as well as in rethinking the competition of green projects and industry 4.0 projects in regional investment markets in the regions of Russia through the lens of a new approach to investment management at the regional level.

2 Literature Review

Investment projects in the field of digitalization of the economy and transition to industry 4.0 are discussed in the works of Barata et al. (2019), Inshakova et al. (2020), Narula et al. (2020), Popkova (2020), Popkova and Sergi (2020a, 2020b), Shvets et al. (2019), and Veile et al. (2019). Green projects designed to improve the environmental situation in economic systems are analyzed in the works of Afum et al. (2020), Bogoviz (2019a, 2019b), Jog and Singhal (2019), Soomro et al. (2020), and Weerasinghe and Ramachandra (2018).

At the same time, competition of green projects and industry 4.0 projects in regional investment markets has hardly been studied, which is a gap in the system of scientific and economic knowledge in the field of sustainable development. a systemic view of the investment attractiveness of innovative projects from the perspective of sustainable development, taking into account both the ratio of risk and profitability, and environmental safety is not formed, which is also a gap that needs to be filled.

3 Materials and Method

The regression analysis method is used for a systematic view of the goals of sustainable development with integrated consideration of risk, profitability and environmental safety in this work. This method determines the contribution of green projects (environmental costs) and industry 4.0 projects (digital costs) to investment risk, investment potential (return on investment) and environmental security. The study is carried out on the example of the regions of Russia with the best position in the rating of the investment climate in 2020. The factual data for the study are summarized in Table 1.

4 Results

In order to gain a systematic understanding of the contribution of competing investment projects to the realization of sustainable development goals in the regions of Russia, taking into account risk, profitability and environmental safety in a comprehensive manner, refer to the results of the regression analysis of the materials of Table 1, illustrated in Figs. 1–3.

Based on Fig. 1, with an increase in environmental protection costs by 1 million rubles. investment risk in the regions of Russia increases. With an increase in the cost of introducing and using digital technologies in the regions of Russia, investment risk decreases. That is, from the point of view of investment risk, projects in the field of industry 4.0 are much more attractive than "green" projects.

Based on Fig. 2, with an increase in environmental protection costs by 1 million rubles. investment potential in the regions of Russia increases. With an increase in the cost of introducing and using digital technologies in the regions of Russia, the investment potential also increases. That is, from the point of view of investment profitability (return on investment), industry projects 4.0 and "green" projects are equivalent (equally attractive).

Based on Fig. 3, with an increase in environmental protection costs by 1 million rubles. environmental safety in the regions of Russia decreases. With an increase in the cost of introducing and using digital technologies in the regions of Russia, environmental safety increases. That is, from the point of view of investment risk, projects in the field of industry 4.0 are much more attractive than green "projects.

Based on the results of the regression analysis (from Figs. 1, 4, 3), a model of competition of green and industry 4.0 projects in regional investment markets has been created from a security perspective (Fig. 4).

The model in Fig. 4 demonstrates a new approach that provides a systematic view of the goals of sustainable development with integrated consideration of risk, profitability and environmental safety, and allows us to rethink the competition of green projects and industry projects 4.0 in regional investment markets in the regions of Russia through the lens of a new approach to investment management at the regional level.

The proposed model presents a new hierarchy of the effectiveness of investment projects in the region. At the lower level are the risks of investment activities, at the middle level the profitability of regional entrepreneurship, and at the highest level the environmental security of the region. The higher the effect of the investment project on the proposed hierarchy, the more investment attractiveness it has.

Table 1 Statistics of green projects, projects in the field of industry 4.0, risk, profitability and security in the regions of Russia in 2020

Position in the investment climate rating in 2020	*Region*	*Investment risk, shares from 1 (the smaller, the better)*	*Investment potential, points 0–10 (the more, the better)*	*Environmental protection costs, million rubles*	*Costs of implementation and use of digital technologies, million rubles*	*Environmental Safety Index, points 1–100*
Maximum Potential—Minimum Risk (1A)	Moscow Region	0.127	6.246	43,705	155,624	49
	Moscow	0.151	14.868	45,266	1,489,891.8	68
	St. Petersburg	0.128	4.999	15,804	87,871.7	66
	Krasnodar Territory	0.166	2.905	12,753	17,296.5	47
Medium Potential—Minimum Risk (2A)	Belgorod region	0.138	1.554	9,056	4732.9	72
	Republic of Tatarstan	0.157	2.474	26,841	31,259.2	60
	Nizhny Novgorod Region	0.194	1.871	14,739	24,009.3	58
	Samara Region	0.19	1.713	16,240	22,167.8	60
	Sverdlovsk Region	0.198	2.487	27,807	33,326.7	47
High potential—moderate risk (1B)	Krasnoyarsk Territory	0.245	2.543	40,383	16,890.4	63

Source Compiled by the authors on the basis of materials from RAEX-Analytics LLC, Expert Expert Rating Agency LLC (RAEX LLC), Expert RA JSC (2021), Green Patrol (2021), and Federal State Statistics Service (2021)

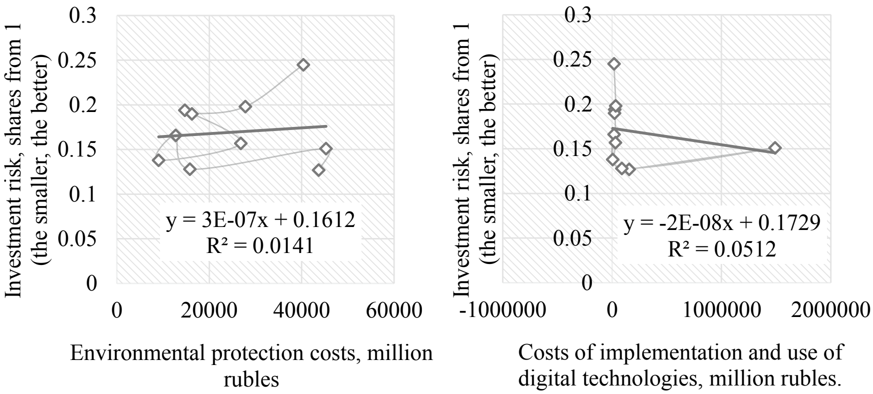

Fig. 1 Regression characterization of the contribution of "green" projects and projects in the field of industry 4.0 to investment risk in the regions of Russia (*Source* Calculated and built by the authors)

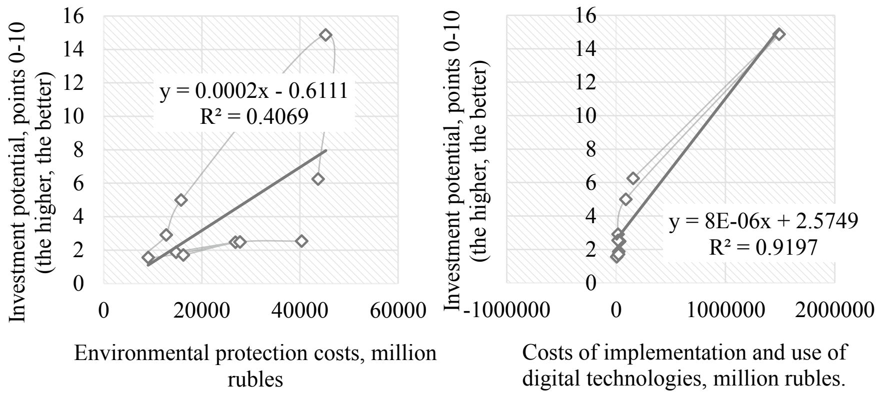

Fig. 2 Regression characteristic of the contribution of green projects and projects in the field of industry 4.0 to the investment potential (return on investment) of the regions of Russia (*Source* Calculated and built by the authors)

The model shows that green projects have a limited short-term effect. Like all investment projects, they are associated with risk, but due to their narrow orientation, they provide profitability for regional entrepreneurship, and on this their potential runs out. In contrast, industry 4.0 projects have a systemic long-term effect, recouping investment risks by generating an effect not only on the profitability of regional entrepreneurship, but also on the environmental security of the region.

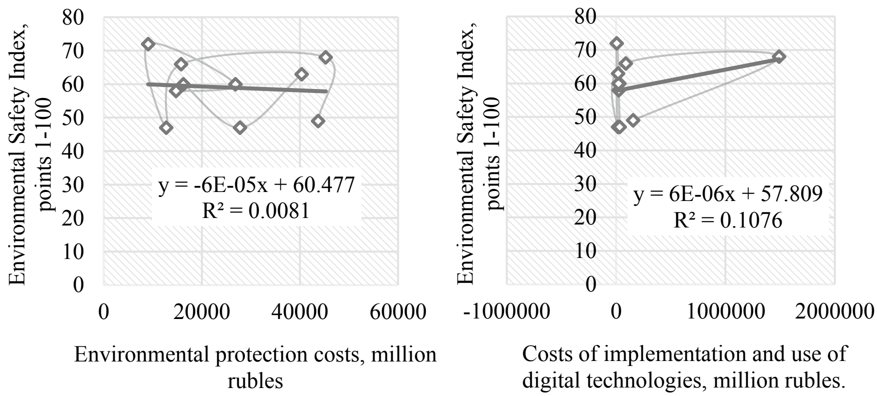

Fig. 3 Regression characterization of the contribution of "green" projects and projects in the field of industry 4.0 to environmental safety in the regions of Russia (*Source* Calculated and built by the authors)

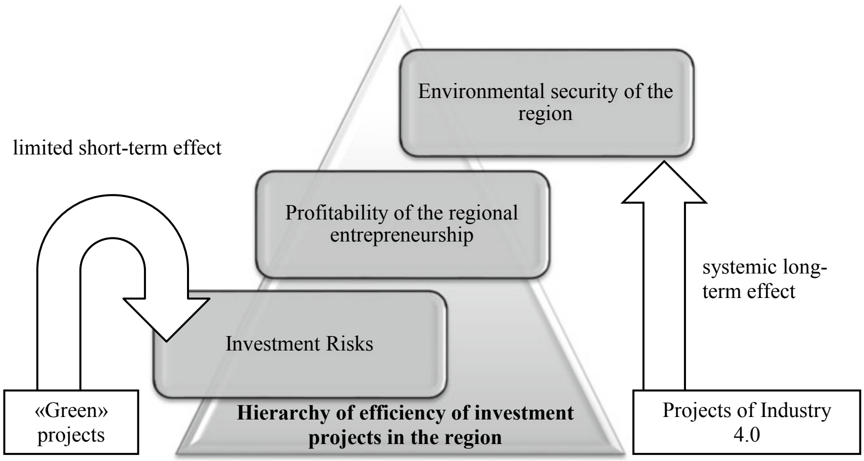

Fig. 4 Green and industry competition model 4.0 in regional security investment markets (*Source* Developed and compiled by the authors)

5 Conclusion

Therefore, it can be concluded that the hypothesis put forward received scientific confirmation. The example of the regions of Russia with the best position in the investment climate rating in 2020 shows that "green" projects have too narrow (environmental) focus, which is not enough for the sustainable development of the region, and therefore are associated with high risks, albeit with high profitability.

Industry projects 4.0 are more competitive (investment attractive), as they are associated with less risk with similar returns, and also provide a contribution to the environmental safety of the region. A wider range of digital projects, beyond environmental protection, underpins their competitive advantage in regional investment markets. However, government regulation of these markets should aim to orient industry projects 4.0 towards the mandatory creation of environmental safety benefits, which involves enhanced monitoring and control.

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Limited Opportunities for Financing Projects in the Field of Industry 4.0 and Combating Climate Change in the Regions of Russia in the Face of Budget Shortages

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1 Introduction

Investment projects in industry 4.0 and the combat against climate change, despite their different orientation, have a common specificity. Despite the long-term commercial advantages expressed, these projects are characterized by moderate or low investment attractiveness for private enterprise due to the need for large investment resources and a long payback period.

That is, they are practically inaccessible, especially for small and medium-sized regional enterprises that do not have sufficient free investment resources of their own, or the ability to attract missing investments (for example, on loan or leasing terms), and also cannot take on the risks of a long-term return on investment due to the high level of entropy of the market environment in the region. Therefore, in order to support these projects that are strategically significant for the region, public authorities finance them (or co-finance) from the regional budget.

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This fundamentally distinguishes breakthrough investment projects in the field of industry 4.0 and the fight against climate change from moderate-innovative investment projects, which are massively available and actively implemented in regional entrepreneurship. Against the backdrop of the worsening problem of budget deficits in the context of the pandemic and crisis, the problem of determining the dependence of financing for projects in the field of industry 4.0 and combating climate change on the regional budget balance was COVID-19 updated.

According to popular opinion, it is generally accepted that as the regional budget balance increases, the funding of the projects under consideration increases. In contrast, this article hypothesizes that the linkage of industry 4.0 and climate change financing with the region's budget balance is more complex, since as the budget surplus increases, the projects in question are second in importance to social projects and are financed on a residual basis.

The purpose of the article is to study the limited possibilities of financing projects in the field of industry 4.0 and the fight against climate change in the regions of Russia in the face of budget shortages amid the pandemic and the COVID-19 crisis, as well as to determine the optimal budgetary conditions for financing these projects.

2 Literature Review

The issues of financing projects in the field of industry 4.0 and combating climate change from budget funds are considered in the works of Bogoviz (2019a, 2019b), Inshakova et al. (2020), Popkova (2020), and Popkova and Sergi (2020a, 2020b). The exacerbation of the problem of budget deficits in the face of a pandemic and crisis COVID-19 is noted in the publications Broadbent. (2020), Haynes (2020), Mai (2020), Mather (2020), and Pitts (2020).

However, the patterns of changes in the volume and adequacy of financing for industry 4.0 and climate change projects are not defined depending on the regional budget balance, nor are the limited possibilities for financing industry 4.0 and climate change projects in regions in the face of budget deficits underestimated. This research is intended to fill these gaps.

3 Materials and Method

In order to determine the most accurate and reliable dependencies of the volume and financing of projects in the field of industry 4.0 and the fight against climate change on the regional budget balance, this study is carried out on the basis of two samples of regions of Russia, formed according to the criterion of the regional budget balance in the context of a pandemic and COVID-19 crisis in 2020.

The first sample included the top 10 regions of Russia with the largest regional budget deficit in 2020. The second sample included the top 10

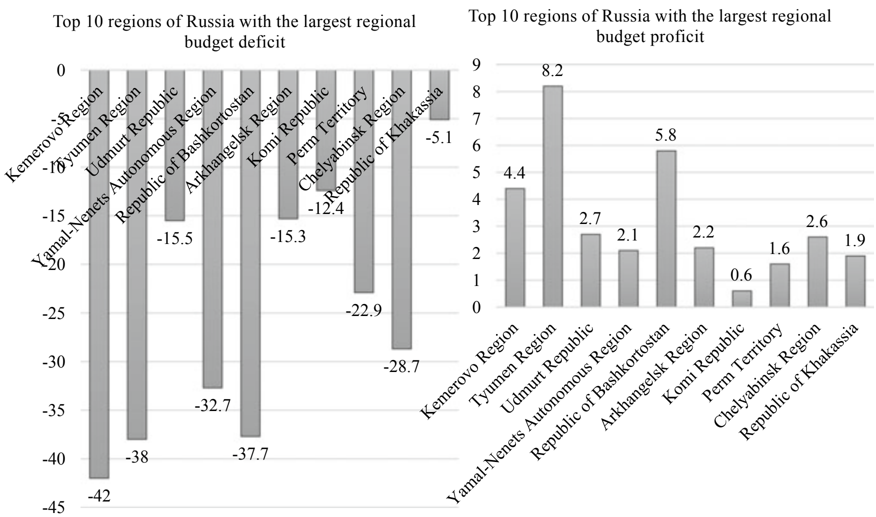

Fig. 1 The balance of the regional budget in samples of regions of Russia in the context of the pandemic and crisis COVID-19 according to the results of 2020, billion rubles (*Source* Built by the authors on the basis of RBK materials [2021])

regions of Russia with the largest regional budget surplus in 2020. The characteristics of the samples are shown in Fig. 1.

Each sample separately examines the regression dependence of industry 4.0 and climate change project funding on the regional budget balance. The data for the study are shown in Tables 1 and 2.

4 Results

The pattern of change in industry 4.0 and climate change project funding in the sample regions is described using the data from Table 2 regression relationships and illustrated in Figs. 2 and 3.

According to Fig. 2, in the top 10 regions of Russia with the largest regional budget deficit according to the results of 2020, as the budget deficit deepens, the total financing of projects in the field of the industry 4.0 and the fight against climate change decreases.

According to Fig. 3, in the top 10 regions of Russia with the largest regional budget surplus according to the results of 2020, as the budget surplus increases, the overall financing of projects in the field of industry decreases 4.0 and the overall financing of projects in the field of climate change increases.

The established patterns formed the basis of the compiled models of financing projects in the field of industry 4.0 and climate change in the regions of Russia, depending on the budget balance (Figs. 4 and 5).

The model in Fig. 4 shows that financing of projects in the field of industry 4.0 is underfunded both with a deficit and a budget surplus in the regions of

Table 1 Financing of projects in the field of the 4.0 industry and the fight against climate change and the budget balance in the top 10 regions of Russia with the largest regional budget deficit following the results of 2020

Region	*Budget deficit, % to income*	*Environmental protection costs, million rubles*	*Costs of implementation and use of digital technologies, million rubles*
Kemerovo Region	−21	17,198	7,298.8
Tyumen Region	−20	55,156	54,100.6
Udmurt Republic	−16	4,068	6,421.4
Yamal-Nenets Autonomous Region	−14	19,447	12,178.6
Republic of Bashkortostan	−14	16,785	20,802.7
Arkhangelsk Region	−14	7,141	3,775.9
Komi Republic	−12	9,157	6,235.0
Perm Territory	−12	15,868	19,087.0
Chelyabinsk Region	−12	17,086	16,536.7
Republic of Khakassia	−12	2,161	1,164.8

Source Compiled by the authors on the basis of materials from RBK (2021) and Federal State Statistics Service (2021)

Russia. With a zero regional budget balance, the point of optimal deficit-free) financing of these projects is reached.

The model in Fig. 5 shows that funding for climate change projects is underfunded with budget deficits in the regions of Russia. With a zero regional budget balance, funding is deficient and the amount of deficient funding increases as the regional budget surplus grows, but only to a certain level, after which it remains unchanged (constant). A confident regional budget surplus forms the zone of optimal financing of climate change projects in the regions of Russia.

5 Conclusion

The results of the research proved the hypothesis and demonstrated that the financing of projects in the field of industry 4.0 and the combat against climate change in the regions of Russia, firstly, is significantly determined by the balance of the regional budget.

Secondly, it is characterized by various laws: financing of projects in the field of industry 4.0 is scarce both with a deficit and a budget surplus, and financing of projects in the field of combating climate change in the regions of Russia is scarce with a budget deficit and enough with a budget surplus.

Table 2 Financing of projects in the field of the 4.0 industry and the fight against climate change and the budget balance in the top 10 regions of Russia with the largest regional budget surplus following the results of 2020

Region	*Budget surplus, % to income*	*Environmental protection costs, million rubles*	*Costs of implementation and use of digital technologies, million rubles*
Chukotka Autonomous Region	8	1,229	787.3
Voronezh Region	5	8,195	5,754.5
Sevastopol	5	776	954.8
Kabardino-Balkarian Republic	4	417	572.0
Altai Territory	4	2,902	5,291.0
Ivanovo Region	3	1,479	1,910.1
Jewish Autonomous Region	3	485	216.8
Republic of Mordovia	3	1,935	1,642.2
Tver Region	3	4,120	8,398.5
Vladimir Region	2	2,932	4,726.3

Source Compiled by the authors on the basis of materials from RBK (2021) and Federal State Statistics Service (2021)

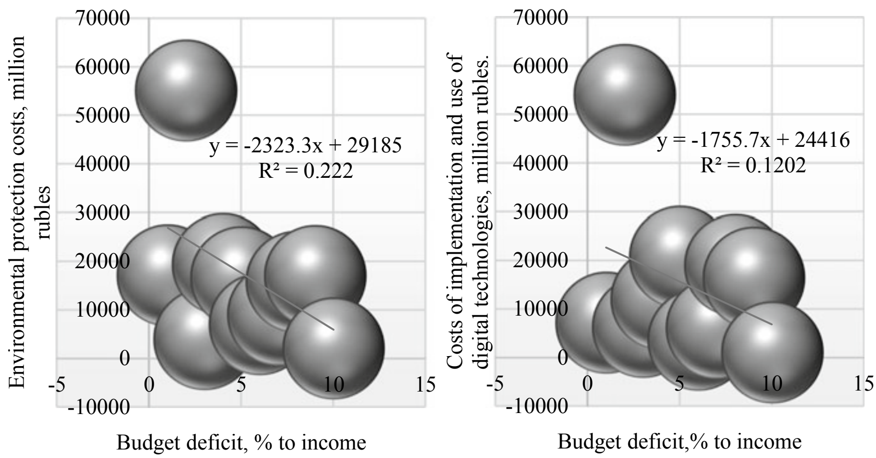

Fig. 2 The pattern of the change in the volume of financing of projects in the field of the industry 4.0 and the combat against climate change in the top 10 regions of Russia with the largest regional budget deficit following the results of 2020 (*Source* Calculated and built by the authors)

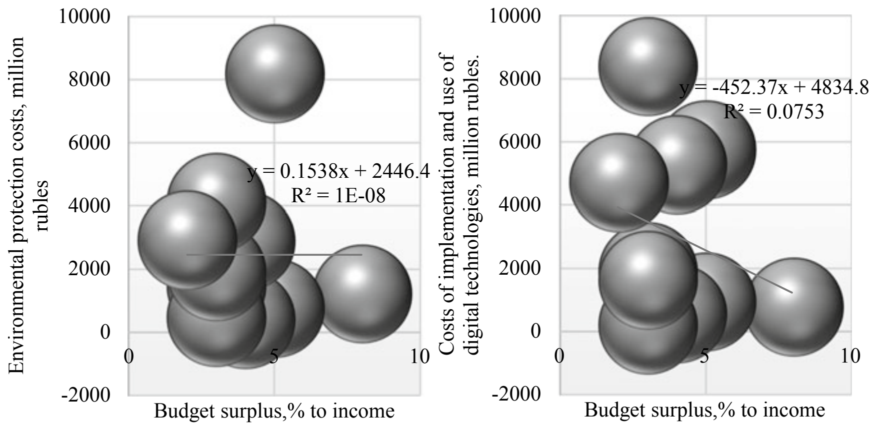

Fig. 3 The pattern of the change in the volume of financing of projects in the field of the 4.0 industry and the fight against climate change in the top 10 regions of Russia with the largest regional budget surplus following the results of 2020 (*Source* Calculated and built by the authors)

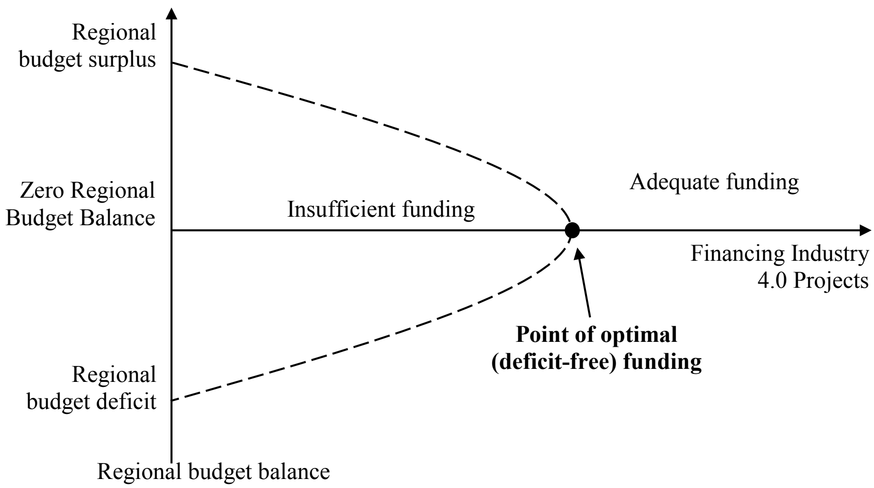

Fig. 4 Model of financing of projects in the field of industry 4.0 in the regions of Russia depending on the budget balance (*Source* Developed and compiled by the authors)

Thirdly, there are different conditions for the optimal budget balance: with a zero regional budget balance, the point of optimal deficit) financing of these projects is reached, and a confident regional budget surplus forms the zone of optimal financing of climate change projects in the regions of Russia.

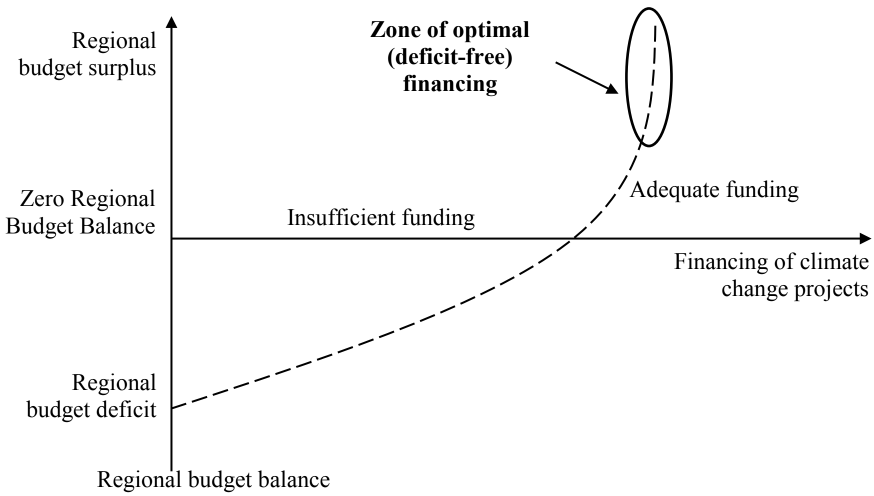

Fig. 5 Funding model for climate change projects in Russian regions depending on budget balances (*Source* Developed and compiled by the authors)

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Scenario of Balanced Development of Industry 4.0 and Green Economy in the Regions of Russia: Financing, Sustainability and Security

Mikhail Yu. Zakharov, Anna V. Ostretsova, Tatiana V. Skryl, and Alexey K. Titov

1 Introduction

When implementing the goals of sustainable development, there is a contradiction in the practice of the regions of Russia. While sustainable development goals are considered to be equivalent, they have been adopted primarily because of concern about the growing negative impacts and future threats of climate change. Therefore, the goals that contribute to the environmental safety of economic systems are put first. As a result, projects in the field of the development of the green economy in the regions of Russia are financed primarily.

In contrast, industry projects 4.0, aimed mainly at improving the socio-economic situation of the regions, are financed in Russia in the second place and according to the residual principle, that is, they are underfunded. This leads to an imbalance in the environmental and socio-economic goals of

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sustainable development in the regions of Russia. The scenario of continuing the current practice will lead to an increase in the already obvious imbalance, as a result of which the regions of Russia will be stable from the standpoint of environmental stability, but will show slow digital socio-economic development due to the information of industry 4.0.

The problem is that this scenario is contrary to the interests of the regions of Russia seeking to systematically achieve the goals of sustainable development. According to the hypothesis of this study, the reason for the problem is the uncertainty of the optimal proportion and, as a result, the uneven financing of the development of industry 4.0 and the green economy in the regions of Russia. That is, by changing the proportion of funding, it is possible to solve the problem under consideration. The research is aimed at testing the hypothesis put forward, developing a scenario for the balanced development of industry 4.0 and the green economy in the regions of Russia, determining the optimal proportion and target amount of financing in the interests of systemic stability and security.

2 Literature Review

The contribution of the digital economy and industry 4.0 to sustainable development is disclosed in Cunha et al. (2020), Inshakova et al. (2020), Narula et al. (2020), Popkova and Sergi (2020a, 2020b), and Sony et al. (2020). The fundamental importance of a green economy in achieving the environmental mission of sustainable development is reflected in the publications of Agyabeng-Mensah et al. (2020), Bogoviz (2019a, 2019b), Singh et al. (2020), and Shahzad et al. (2020).

Therefore, the literary review revealed a rather detailed elaboration of the issues of ensuring sustainable development on the basis of the digital economy and industry 4.0, on the one hand, and the green economy, on the other hand. At the same time, the relationship between the importance of digitalization and environmental safety for sustainable development at the regional level is not defined, as well as the requirements for the distribution of financing between digital and green projects in the region, which constitutes research gaps. In order to fill the identified gaps, it is necessary to develop a scenario for the balanced development of industry 4.0 and the green economy in the regions of Russia and its detailed study from the points of view of financing, sustainability and security, to which this work is devoted.

3 Materials and Method

The economic and mathematical meaning of the hypothesis put forward is that it should be revealed:

1. The positive regression dependence of the polar index, reflecting the level of sustainability of the development of the Arctic regions of Russia (Psdi),

on the environmental ("green") index (gr) and the level of digitalization (industry 4.0, dg). To do this, the function is composed: Psdi = F (ar, dg);
2. Positive regression dependence of the environmental (green) index (gr) on environmental expenditure (f_{dg}). In order do this, the function is compiled: gr = F (f_{dg});
3. Positive regression dependence of the level of digitalization (industry 4.0, dg) on the cost of implementing and using digital technologies (f_{gr}). In order to do this, the function is composed: dg = F dg = F (f_{gr}).

Based on the established regression dependencies, firstly, the required level of digitalization and environmental index is determined to achieve the maximum value by the polar index (1) and, secondly, the target values of environmental costs and digitalization to achieve the required level of development of the green economy and industry 4.0—this is a quantitative description of the scenario of balanced development of industry 4.0 and the green economy in the regions of Russia from the points of view of financing, sustainability and security. The empirical basis of the research is given in Table 1.

4 Results

In order to develop a scenario of balanced development of industry 4.0 and green economy in the regions of Russia from the point of view of financing, sustainability and safety, the regression dependence Psdi = F (ar, dg) was determined, which turned out to be as follows:

$$\mathrm{Psdi} = 0.6124 - 0.0008 * \mathrm{ar} + 0.0010 * \mathrm{dg}.$$

Therefore, with an increase in the level of digitalization (industry 4.0, dg) by 1 point, the polar index reflecting the level of sustainability of the development of the Arctic regions of Russia (Psdi) increases by 0.0010. At the same time, the polar index shows a negative dependence on the environmental ("green") index (gr). Based on this, the target values of the level of digitalization are determined according to the scenario of balanced development of industry 4.0 and the "green" economy in the regions of Russia with an unchanged environmental ("green") index (Table 2).

The regression dependence of the environmental (green) index (gr) on environmental protection costs (f_{dg}) is determined in order to determine the prospects for achieving the identified target values of the level of digitalization according to the scenario of balanced development of industry 4.0 and green economy in the regions of Russia (Fig. 1).

According to Fig. 1, the green environmental index cannot be increased by increasing the amount of environmental expenditure (regression dependence inverse, negative). The regression dependence of the environmental (green) index (gr) on the costs of implementing and using digital technologies (f_{gr})

Table 1 Statistics on the development of industry 4.0 and green economy in the regions of Russia from the point of view of financing, sustainability and security in 2021

Region	*Polar index, shares from 1*	*Environmental (green index, points 1–100)*	*Digitalization level (forecast for 2021), points 1–100*	*Environmental protection costs, million rubles*	*Costs of implementation and use of digital technologies, million rubles*
	Psdi	*gr*	*dg*	*fgr*	f_{dg}
Murmansk Region	0.673	54	63.15	27,253	3,733.5
Republic of Sakha (Yakutia)	0.670	46	62.19	20,233	8,560.8
Arkhangelsk Region	0.631	44	44.70	7,141	3,775.9
Yamal-Nenets Autonomous Region	0.628	41	68.03	19,447	12,178.6
Krasnoyarsk Territory	0.620	35	57.81	40,383	16,890.4
Chukotka Autonomous Region	0.604	53	25.95	1,229	787.3
Republic of Karelia	0.602	55	38.65	2,991	2,816.1
Nenets Autonomous Region	0.595	62	40.62	562	764.1
Komi Republic	0.590	63	58.54	9,157	6,235.0

Source Compiled by the authors on the basis of the materials Green Patrol (2021), Institute of Scientific Communications (2021), Rosstat (2021), Expert Center Project Office for Arctic Development "PORA," Department of Environmental Economics of the Faculty of Economics of Moscow State University named after M.V. Lomonosov (2021)

was also negative (Fig. 2), which indicates the inaccessibility of the financial mechanism for environmental safety management in the regions of Russia.

The regression dependence of the level of digitalization (industry 4.0, dg) on the cost of implementing and using digital technologies (f_{gr}) in Fig. 3, which turned out to be positive (direct relationship of indicators), was also determined.

In accordance with Fig. 3, with an increase in the cost of implementing and using digital technologies (fgr) by 1 million rubles. the level of digitalization (industry 4.0, dg) increases by 0.0018 points. Based on this, the target costs for the implementation and use of digital technologies are calculated (Fig. 4).

Table 2 Target values of the level of digitalization according to the scenario of balanced development of industry 4.0 and green economy in the regions of Russia (with them Psdi = 1 in each region)

Region	*Digitalization level, points 1–100*	
	Target indicators, points	*Target gain, times*
Murmansk Region	424.23	6.72
Republic of Sakha (Yakutia)	417.88	6.72
Arkhangelsk Region	416.29	9.31
Yamal-Nenets Autonomous Region	413.91	6.08
Krasnoyarsk Territory	409.14	7.08
Chukotka Autonomous Region	423.44	16.32
Republic of Karelia	425.03	11.00
Nenets Autonomous Region	430.59	10.60
Komi Republic	431.38	7.37
Average for polar Regions	421.32	8.25

Source Calculated and compiled by the authors

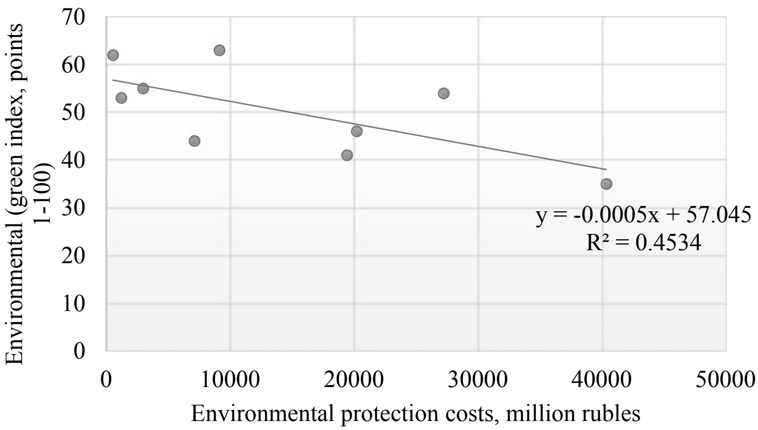

Fig. 1 Regression dependence of environmental (green) index (gr) on environmental costs (f_{dg}) (*Source* Calculated and built by the authors)

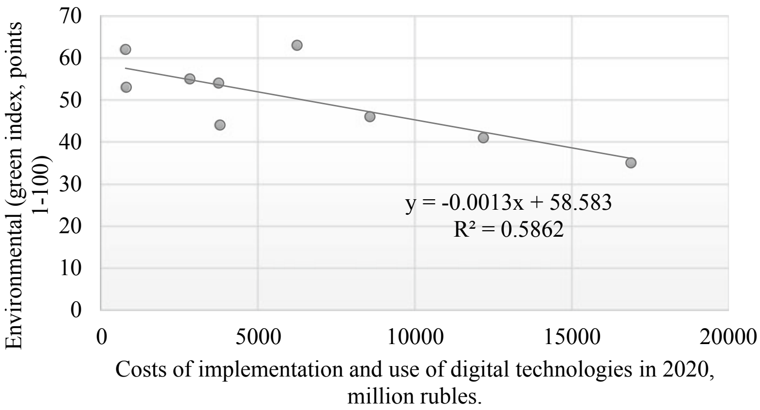

Fig. 2 Regression dependence of the environmental (green) index (gr) on the costs of implementing and using digital technologies (f_{gr}) (*Source* Calculated and built by the authors)

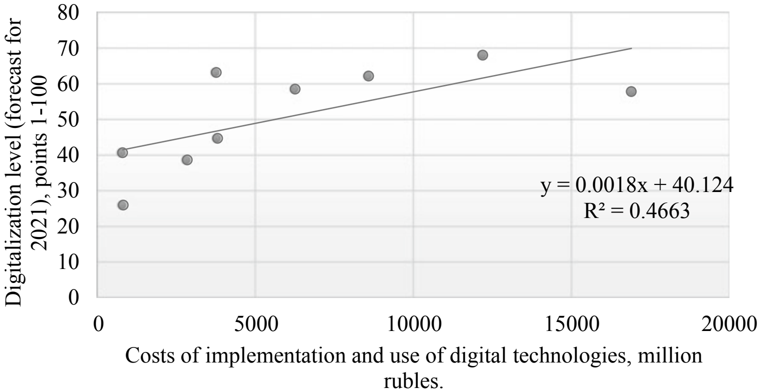

Fig. 3 Regression dependence of digitalization level (industry 4.0, dg) on costs of implementation and use of digital technologies (f_{gr}) (*Source* Calculated and built by the authors)

Figure 4 shows the target cost of implementing and using digital technologies in order to achieve the required optimal digitalization level values from Table 2 in each Arctic region of Russia.

5 Conclusion

In such a way, a scenario of balanced development of industry 4.0 and green economy in the regions of Russia was formed. It was revealed that for the sustainable development of the Arctic regions of Russia, digitalization and the

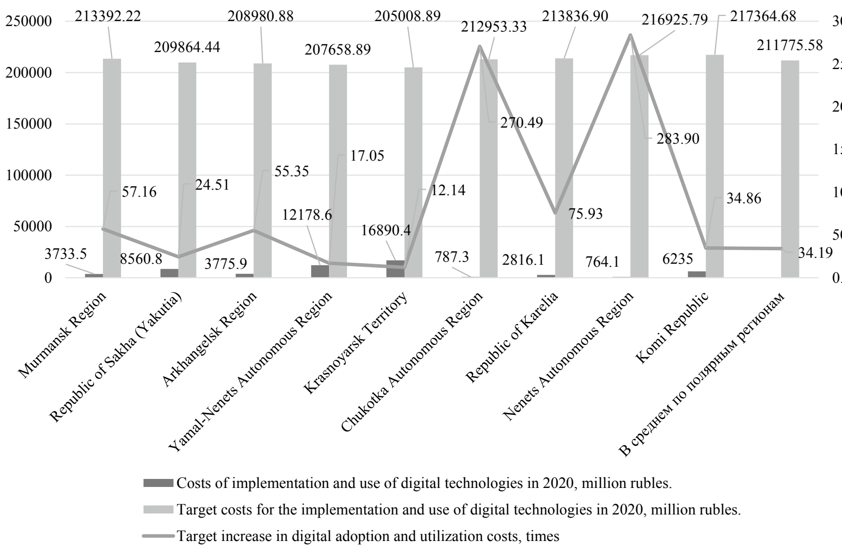

Fig. 4 Target costs for the introduction and use of digital technologies according to the scenario of balanced development of industry 4.0 and green economy in the regions of Russia (with them Psdi = 1 in each region) (*Source* Calculated and compiled by the authors)

transition to industry 4.0 are most important, which should be accelerated by an average of 8.25 times. In order to do this, the amount of financing for digitalization should increase by 34.19 times.

This indicates a fundamental possibility, but dubious feasibility in practice of financing sustainable development in the Arctic regions of Russia and the feasibility of finding alternative—non-financial mechanisms. Financial management is not applicable to the green economy and, therefore, prospects for achieving the environmental goals of sustainable development, contrary to the hypothesis, need to be studied in depth, to which future scientific research is proposed.

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Financial Concept of Limiting the Negative Impact of Industry 4.0 on the Environment in the Regions of Russia in the Interests of Safety

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1 Introduction

Industry 4.0 is the embodiment of the technological breakthrough of our time, but at the same time the transition to a technocratic society and a high-tech economy is associated with unprecedented and sharp distance from nature and alienation of environmental values. The goals of sustainable development are designed to smooth this transition in the context of the fourth industrial revolution, but the experience of all previous revolutions clearly indicates their high risks to environmental safety.

This raises the problem of limiting the negative impact of industry 4.0 on the environment. Study and solve this problem most preferably at the level of regions within countries in order to take into account the specifics of regional

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farms. The search for sources of solutions to the problem, among which financial sources as the most accessible and effective mechanisms of government regulation, have the most obvious promise, becomes relevant.

Direct placement of "green" public investments shows low efficiency, since it does not directly affect the industry 4.0 and does not reduce its environmental costs, but only fights with the negative consequences that have already arisen, that is, it restores the environment. Public co-financing of "green" digital investments of private enterprises to increase the environmental efficiency of the industry 4.0 is also associated with low efficiency due to the excessive burden on the state budget, especially in the context of the 2020 crisis.

This paper suggests (hypothesis) that the optimization of the sectoral structure of the digital regional economy is the preferred alternative to financial management of industry development 4.0. The purpose of the article is to develop a financial concept of limiting the negative impact of industry 4.0 on the environment in the regions of Russia in the interests of ensuring their safety.

2 Literature Review

The negative impact of industry 4.0 on the environment is noted in numerous existing studies and publications, including Bogoviz et al. (2018b), Ibrahiem and Hanafy (2020), Parrish et al. (2020), Popkova (2018), and Vu and Dang (2020). Financial approaches to mitigate the negative impact of industry 4.0 on the environment, such as green investments and environmentally efficient digital innovations, are proposed and discussed in the works of Amidi et al. (2020), Bogoviz et al. (2018a), Bolgova (2017), Medentseva (2017), Popkova et al. 2020), and Zeng et al. (2020).

However, there is no holistic financial concept to limit the negative impact of industry 4.0 on the environment for safety, and there is a shortage of ready-made applications for the regions. Both gaps are intended to fill the research.

3 Materials and Method

In order to test the hypothesis, the regression method determines the regression dependence of the consolidated environmental index reflecting the state of the environment on the level of industry development 4.0 (digitalization) in the largest agglomerations of Russia in 2020 (Table 1).

In order to determine the dependence of industry 4.0 on the environment on the sectoral structure of the economy, the study is carried out on the example of different samples of the region, formed according to the criterion of the level of resilience to the crisis, determined by Basetop (2021) taking into account the sectoral structure of gross regional product (GRP). Three samples are generated from Table 1 (Fig. 1):

Table 1 Industry 4.0, state of environment and stability of agglomerations and their regions in Russia in 2020

No.	*Region*	*Agglomeration*	*Potential agglomeration resilience to crisis events in 2020, points 1–100*	*GDP per capita, RUB*	*Industry level 4.0 (digitalization), points 1–100*	*Environmental index (summary), points 1–100*
1	Perm Territory	Perm	72.09	409.8	52.32	63
2	Chelyabinsk Region	Chelyabinsk	70.54	327.4	61.62	46
3	Saratov Region	Saratov	69.71	282.5	35.38	56
4	Krasnoyarsk Territory	Krasnoyarsk	69.37	368.7	57.81	47
5	Republic of Bashkortostan	Ufa	68.39	477.1	67.05	58
6	Primorsky Territory	Vladivostok	68.16	443.3	51.25	50
7	Volgograd Region	Volgograd	67.54	291.2	51.61	57
8	Samara Region	Samara and Tolyatti	67.39	366.8	61.01	60
9	Rostov Region	Rostov	66.73	342.4	63.76	61
10	Voronezh Region	Voronezh	66.68	357.4	63.44	58
11	Republic of Tatarstan	Kazan	66.54	434.5	70.01	60
12	Nizhny Novgorod Region	Nizhny Novgorod	66.45	436.2	61.52	58
13	Novosibirsk Region	Novosibirsk	65.65	335.1	54.07	54
14	Sverdlovsk Region	Ekaterinburg	64.21	482.7	54.88	47
15	Krasnodar Territory	Krasnodar	62.31	472.5	54.37	63
16	Leningrad Region	St. Petersburg	58.21	687.0	64.34	55
17	Moscow Region	Moscow	50.64	1,157.9	67.60	32

Source Compiled by authors based on Basetop (2021), Green Patrol (2021), and Institute of Scientific Communications (2021)

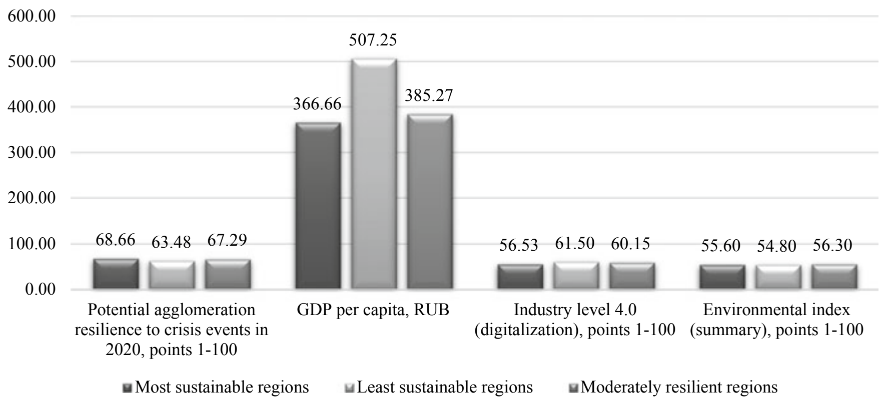

Fig. 1 Characteristics of samples of Russian regions on crisis resistance in 2020 (*Source* Calculated and built by the authors)

- Most sustainable regions (1–10);
- Least sustainable regions (8–17);
- Moderately stable regions (4–13).

A full sample of 1–17 regions is also being studied.

4 Results

In order to identify differences in the environmental impact of industry 4.0 in different regions of Russia in 2020, refer to the regression statistics in Figs. 2–5.

According to Fig. 2, with an increase in the level of industry development

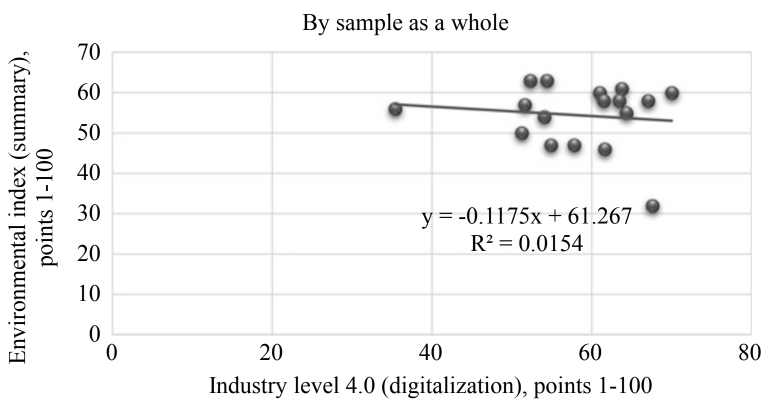

Fig. 2 Regression statistics of the environmental impact of industry 4.0 in a full sample of Russian regions in 2020 (*Source* Calculated and built by the authors)

4.0 in the full sample of regions (from Table 1) of Russia by 1 point, the environmental index decreases by 0.1175 points, which indicates a deterioration of the environment.

According to Fig. 3, with an increase in the level of industry development 4.0 in the least stable regions of Russia by 1 point, the environmental index decreases by 0.2798 points, which indicates an even greater deterioration of the environment under the influence of digitalization than in the full sample of regions. Therefore, with this structure of the region's economy, it is prone to crisis phenomena and is not stable, which increases the environmental costs of industry 4.0.

According to Fig. 4, with an increase in the level of industry development 4.0 in the most stable regions of Russia by 1 point, the environmental

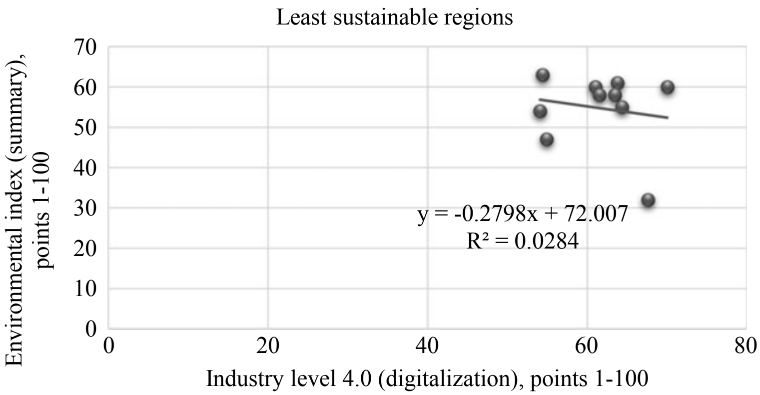

Fig. 3 Regression statistics of the environmental impact of industry 4.0 in the least sustainable regions of Russia in 2020 (*Source* Calculated and built by the authors)

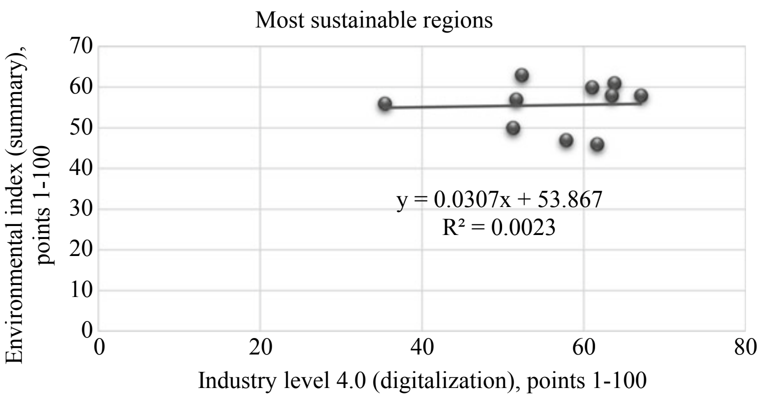

Fig. 4 Regression statistics of the environmental impact of industry 4.0 in the most stable regions of Russia in 2020 (*Source* Calculated and built by the authors)

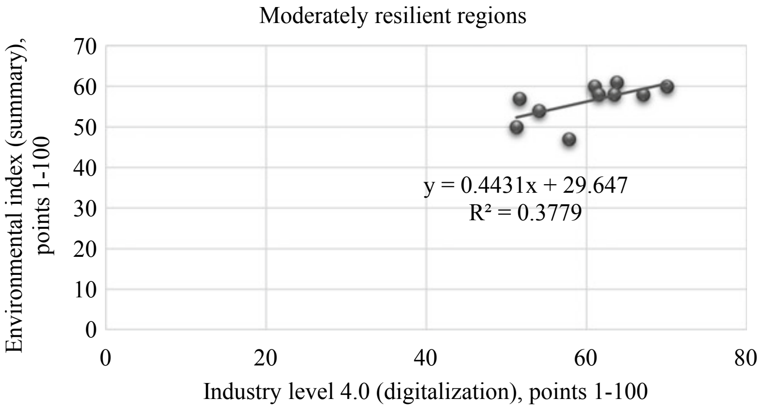

Fig. 5 Regression statistics of industry 4.0 impact on the environment in moderately stable regions of Russia in 2020 (*Source* Calculated and built by the authors)

index increases by 0.0307 points, which indicates an improvement in the environment.

According to Fig. 5, with an increase in the level of industry development 4.0 in moderately stable regions of Russia by 1 point, the environmental index increases by 0.4431 points, that is, 14.43 times more than in the most stable regions. This indicates an improvement in the environment. Based on the results of the regression analysis, the financial concept of limiting the negative impact of industry 4.0 on the environment in the regions of Russia in the interests of security is proposed, which involves the flexibility of the GRP industry structure and the search for a balance between the development of market relations and state regulation.

5 Conclusion

Therefore, it has been proved that the industry structure of GRP significantly determines the nature of the influence of industry 4.0 on the environment in the regions of Russia. In regions with a predominance of market relations (least resilient to the crisis), the impact of industry 4.0 on the environment is negative. In regions based on the public sector and regulation, a positive but positive effect is most pronounced in regions with a combination of market and government regulation (moderately resistant to the 2020 crisis).

The studied experience of different samples of regions of Russia made it possible to form a financial concept of limiting the negative impact of industry 4.0 on the environment in the interests of ensuring safety, which involves a transformation of the sectoral structure of the region's economy. Although each region has to choose its own balance of market and state forces, it is not recommended to focus on a clean market. In times of crisis, the region's resilience determines its possibilities for balanced development of society, economy and environmental protection. In this regard, the experience of the regions of Russia can be useful for the regions of other countries around the world.

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Financing of Responsible Production in Regional Entrepreneurship Based on the Capabilities of Industry 4.0: Contribution to the Environmental Safety of the Region

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1 Introduction

Financing is the cornerstone of responsible production in today's regional economy, as the ongoing economic crisis caused by the COVID-19 pandemic puts most enterprises around the world in short supply or on the brink of loss. With the combination of industry finance 4.0 and corporate environmental responsibility, the lack of resources is especially acute, which increases the risks of digitalization for the environmental safety of the regions.

A promising solution to the problem of lack of own funds among enterprises is the diversification of sources of financing of responsible industries. One of the sources that traditionally supplement the enterprises' own funds is bank lending, which includes leasing. Its advantage is mass accessibility for enterprises on favorable terms, but the disadvantage is the payment of interest

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on loans, which is why in many cases bank lending does not solve the problem of lack of financial resources for enterprises, but only exacerbates it.

Another source is federal funding for responsible industries. It does not impose a burden on the regional budget and is a form of subsidy for the development of the regional economy, but at the same time is associated with insufficient control of environmental consequences for the region, as it is designed to co-finance the transition to industry 4.0 without taking into account the consequences for environmental safety. And another source is funding from the regional budget. It allows for full-scale environmental control of responsible industries, but causes a high burden on the region.

This study is aimed at determining the features of financing responsible industries in Russian regional entrepreneurship based on the capabilities of industry 4.0, determining the contribution of various sources of financing digital innovations to ensuring the environmental safety of Russian regions and selecting for each of them an optimal approach to diversifying sources of financing.

2 Literature Review

A literary review on the topic of the study showed that the features of financing responsible industries in modern entrepreneurship have been studied by scientists such as Bergset (2018), Dong et al. (2020), Rahman et al. (2020), and Song et al. (2018). The significant contribution of responsible industries to environmental safety is justified by authors such as Ahmed et al. (2020), Bogoviz et al. (2019), Harjoto and Laksmana (2020), He et al. (2020), Kumar and Anbanandam (2020), and Popkova et al. (2019).

At the same time, the gap analysis revealed points that are not sufficiently developed in the available studies and publications (gaps), including the lack of understanding of the regional aspect of the contribution of financing responsible industries to environmental safety, as well as the uncertainty of the relationship between financing responsible industries and the capabilities of industry 4.0. This study is being conducted to fill these gaps.

3 Materials and Method

In order to clarify the connection of financing of responsible industries with the capabilities of industry 4.0, the leaders of the rating on the Digital Russia index compiled by the Center for Financial Innovation and Cashless Economics of the Moscow School of Management Skolkovo (2021) were selected as objects for study, in which the level of industry development 4.0 is reflected in Fig. 1.

In the selected regions, the regression dependence of environmental safety in 2020 on the use of various sources of financing for responsible production in regional entrepreneurship is determined on the basis of data from Table 1.

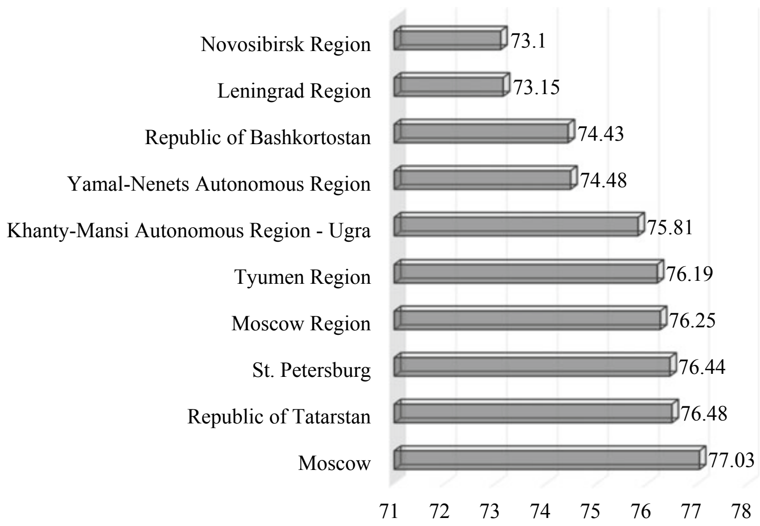

Fig. 1 Industry development level 4.0 in the leading regions of the rating according to the index "Digital Russia," points 1–100 (*Source* Built by the authors on the basis of materials from the Center for Financial Innovation and Cashless Economics of the Moscow School of Management "Skolkovo" [2021])

In accordance with the regression equation obtained, each region determines its own optimal structure of funding sources for responsible industries by simplex method in order to most fully take into account the conditions of optimization: the total share of all sources should be 100%, and the industrial-environmental index should reach 100 points.

4 Results

In order to substantiate the significant differences between sample regions, Table 2 provides descriptive statistics of the data from Table 1.

As shown in Table 2, the share of sources of financing of responsible production in regional entrepreneurship based on the capabilities of industry 4.0 varies greatly among the regions of Russia: the sample dispersion is highest (198.80%) for own funds. On average, their share is 55.68%, and it is maximum in the overall funding structure. Based on the data from Table 1, the following multiple linear regression equation is obtained:

$$PEI = 66.40 - 0.35f_1 - 0.11f_2 - 2.30f_3 + 2.12f_4 \quad (1)$$

According to Eq. (1), with an increase in the share of own funds in the structure of sources of financing for responsible industries in regional entrepreneurship based on the capabilities of industry 4.0 by 1%, the industrial environmental index decreases by 0.35 points. With an increase in the share of

Table 1 Sources of financing of responsible production in the regional enterprise of Russia and consequences for environmental safety in 2020

Region	*Structure of investments in fixed assets of enterprises by sources of financing, %*				*Industrial and environmental index, points 1–100*
	Own funds	*Bank loans*	*Federal budget funds*	*Regional budget funds*	
	f_1	f_2	f_3	f_4	*PEI*
Moscow	50.5	9.4	5.2	17.8	70.0
Republic of Tatarstan	61.6	8.6	3.7	9.5	46
St. Petersburg	60.1	6.9	5.8	9.7	59
Moscow Region	48.1	10.6	6.2	6.0	34.0
Tyumen Region	67.7	12.4	0.3	3.1	49
Khanty-Mansi Autonomous Region—Ugra	85.1	6.4	0.3	1.5	35
Yamal-Nenets Autonomous Region	45.9	21.8	0.1	2.3	60
Republic of Bashkortostan	53.2	14.2	7.2	10.8	53
Leningrad Region	32.8	6.7	8.5	2.9	39
Novosibirsk Region	51.8	7.3	11.2	10.1	50

Source Compiled by the authors on the basis of the materials Green Patrol (2021) and Federal State Statistics Service (2021)

bank loans by 1% by 1%, the industrial environmental index decreases by 0.11 points. With an increase in the share of federal budget funds by 1%, the industrial environmental index decreases by 2.30 points. And only with an increase in the share of regional budget funds by 1% does the industrial environmental index increase by 2.12 points.

Consequently, funding from the regional budget is most preferred. Based on the calculated regression Eq. (1), the optimal structure of investment in fixed assets of enterprises by source of financing for each sample region was determined (Fig. 1).

As shown in Fig. 2, in almost all regions (except the Yamalo-Nenets Autonomous Region), the predominance of regional budget funds is recommended. The recommended increase in the share of financing from this source compared to its share in the structure of investments in fixed assets of enterprises in 2020 is illustrated in Fig. 3.

Table 2 Descriptive statistics of sources of financing of responsible production in Russian regional entrepreneurship

Descriptive statistics	*Own funds*	*Bank loans*	*Federal budget funds*	*Regional budget funds*
Average	55.68	10.43	4.85	7.37
Standard error	4.46	1.51	1.19	1.63
Median	52.50	9.00	5.50	7.75
Mode	n/d	n/d	0.30	n/d
Standard deviation	14.10	4.76	3.76	5.14
Sample variance	198.80	22.69	14.15	26.47
Excess	1.51	3.14	-0.84	0.23
Asymmetry	0.69	1.71	0.06	0.73
Interval	52.30	15.40	11.10	16.30
At least	32.80	6.40	0.10	1.50
At most	85.10	21.80	11.20	17.80
Sum	556.80	104.30	48.50	73.70
Account	10.00	10.00	10.00	10.00
Reliability level (95.0%)	10.09	3.41	2.69	3.68

Source Calculated and compiled by the authors

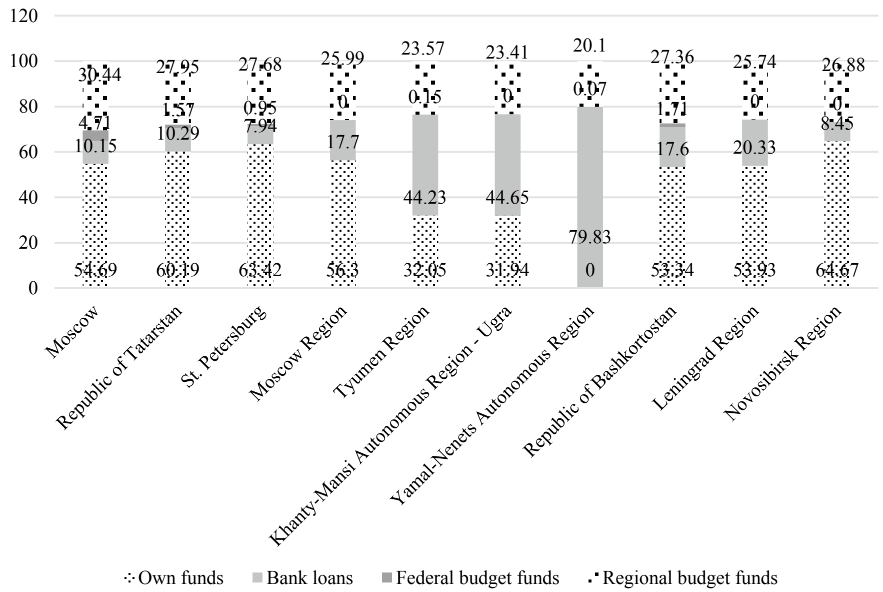

Fig. 2 Optimal structure of investments in fixed assets of enterprises by sources of financing for each sampling region, % (*Source* Calculated and built by the authors)

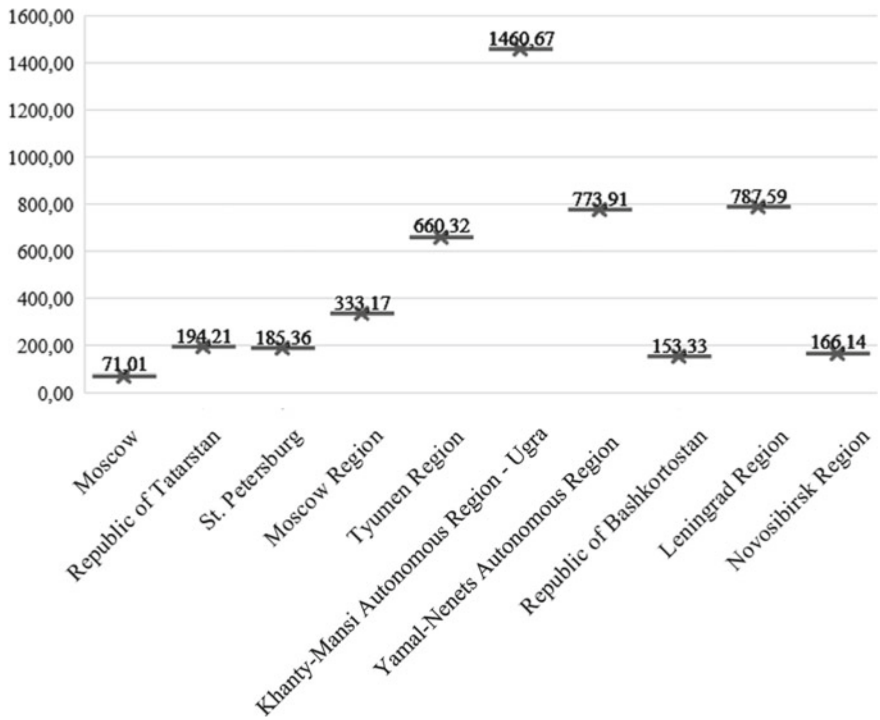

Fig. 3 Recommended increase in the share of funding from the regional budget compared to its share in 2020, % (*Source* Calculated and built by the authors)

According to Fig. 3, the recommended increase in the share of financing from the regional budget compared to its share in 2020 is the largest in the Khanty-Mansi Autonomous Region (1460.67%), as well as quite large in the Tyumen Region (660.32%), Yamalo-Nenets Autonomous Region (773.91%) and Leningrad Region (787.59%). In other regions, it is also very large (multiple), but does not exceed 350%.

5 Conclusion

Summarizing the results of the research, it should be noted that the financing of responsible production in regional entrepreneurship based on the capabilities of industry 4.0 is highly differentiated and should take into account the characteristics of each individual region. Even in the leading regions of Russia in terms of industry 4.0 development, the differences are so great that the development of universal solutions is not available.

Financing of responsible industries in regional entrepreneurship makes a significant contribution to ensuring the environmental safety of the region, but only if the financing structure is optimal. The most preferred source is funding from the regional budget, the share of which is recommended to be significantly increased in the regions of Russia.

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Financing Climate Change in a "Smart" Region for Security: A Fiscal Framework Against Private Investment

Vladimir S. Osipov, Sergei B. Chernov, Aleksandra V. Zakharova, and Natalia N. Nikolashina

1 Introduction

"Smart" regions are actively being created around the world in both developed and developing countries. Their main purpose is to ensure the greatest transparency, control and regularity of the regional economy, as well as the predictability of its development and automation of a number of management functions, primarily through digital monitoring and intelligent analytics of Big Data on various economic processes in the region.

Environmental protection is one of the common uses of smart regions. But the problem is that this direction covers mainly non-financial aspects of the green economy of the region, in particular, controlling the consumption of resources and energy, automating economic processes to reduce their resource and energy intensity, while the most serious barrier to combating climate change is the shortage and not the optimality of financing.

Addressing this challenge involves expanding the use of smart technologies in modern regions to cover climate finance. But this is hampered by the ambiguity of the distribution of roles between the state and private

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entrepreneurship. The basic concept of a smart region involves the participation of exclusively public authorities in the management of the regional economy, which makes it unsuitable for climate finance, in which private investment is important.

It is therefore necessary to determine the importance of the fiscal mechanism and private investment mechanism in financing climate change in the smart region in the interest of security, and on the basis of this relationship, to clarify the concept of the smart region so that it allows private business to participate and to optimally allocate the financial burden, avoiding excessive pressure on the regional budget. The purpose of the research is to develop a model for climate finance in a "smart" region for environmental safety.

2 Literature Review

The underlying principles and empirical experience in combating climate change are reflected in the publications of Bogoviz et al. (2019b), Boumaraf and Amireche (2020), Charnock and Hoskin (2020), Huynh et al. (2020), Leal-Filho et al. (2020), and Sukumaran and Lanke (2020). The specifics of the organization of smart regions and their advantages are reflected in the works of Bogoviz (2020), Bogoviz et al. (2019a), Chen et al. (2020), Li and Padwal (2020), and Lindkvist et al. (2020). Advanced developments in public–private partnerships are outlined in Akopova et al. (2020a, 2020b, 2020c).

At the same time, gaps remain in the relationship between the contribution of the fiscal and private investment mechanism and the organization of climate finance in "smart" regions in order to ensure environmental safety. The research is being conducted to fill these gaps.

3 Materials and Method

This research is carried out on the example of "smart" regions of modern Russia. For study regions with the greatest value of the index of digitalization of municipal economy "IQ of the cities" in each of the allocated sizes of the cities are selected (as reduction: the largest, large, big cities and administrative centers). The values of the index under consideration in the regions included in the sample of this study in 2020 are presented in Fig. 1.

As shown in Fig. 1, the largest value of the index under consideration is typical for Moscow (81.19 points) and the Moscow region (Reutov: 71.35 points). In order to determine the importance of the fiscal mechanism and the private investment mechanism in financing climate change in the smart region in the interests of security and their ratio, a correlation analysis method is used in the work.

The dependence of the environmental safety index (as an indicator of the effectiveness of the fight against climate change) on the state's environmental spending and the share of organizations implementing environmental

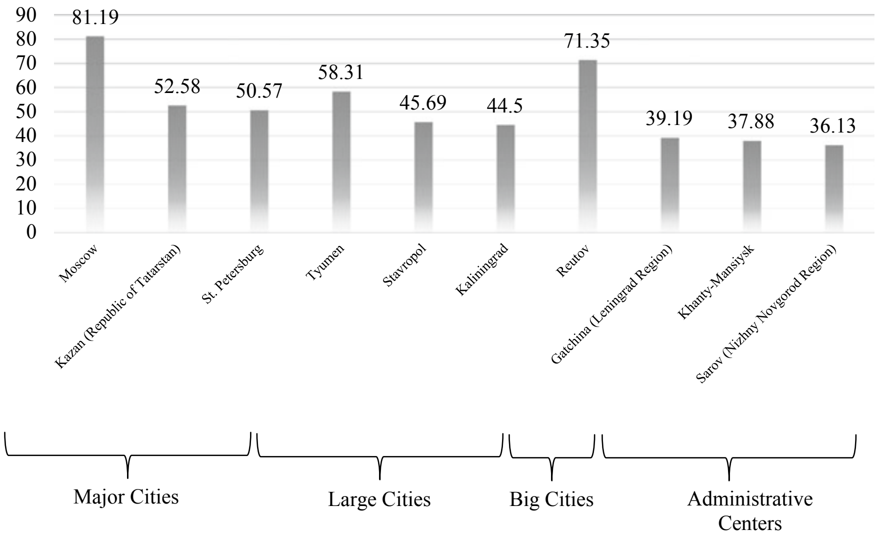

Fig. 1 Index of digitalization of urban economy “IQ cities” of different sizes in Russia in 2020, points 1–100 (*Source* Built by the authors on the basis of materials of the Ministry of Construction of Russia [2021])

innovations is determined. The greater the positive value of the correlation coefficient, the greater the value of the fiscal or private investment mechanism, respectively. The correlation is calculated separately for regions with smart cities of different sizes based on the data from Table 1.

4 Results

In order to determine the specifics of the contribution of the fiscal and private investment mechanism to climate change financing in “smart” regions of Russia of different sizes, refer to the results of correlation analysis of data from Table 1 (Fig. 2).

According to Fig. 2, in the largest cities, both fiscal (38% correlation) and private investment (36%) mechanisms make an equal and important contribution to climate finance. In large cities, the importance of the private investment mechanism is similar (45%), and the fiscal mechanism is much higher (75%). In large cities and administrative centers, both mechanisms do not contribute to the fight against climate change.

The results indicate that the financing of climate change in smart cities in Russia is fragmented and not optimal, and the prospects for its improvement are associated with the simultaneous use of both the fiscal and private investment mechanisms. To this end, a model based on public–private partnerships has been developed, thereby providing a flexible combination of both mechanisms (Fig. 3).

Table 1 Statistics on the financing and impact of the fight against climate change in the smart regions of Russia in 2020

Group	*Region*	*Environmental protection costs, million rubles*	*Percentage of organizations innovating to reduce pollution**,%*	*Environmental Safety Index (Summary), points 1–100*
Major Cities	Moscow	45,266	80.0	68
	Republic of Tatarstan	26,841	73.3	60
	St. Petersburg	15,804	69.0	66
Large Cities	Tyumen Region (without autonomous districts)	4,086	77.8	64
	Stavropol Territory	5,282	100.0	59
	Kaliningrad Region	1,733	66.7	51
Big Cities Administrative Centers	Moscow Region	43,705	93.3	49
	Leningrad Region	16,036	76.9	55
	Khanty-Mansi Autonomous Region	31,623	75.0	50
	Nizhny Novgorod Region	14,739	85.2	58

*(less than 100 thousand people) and pilot municipalities, on the territory of which it is planned to introduce Smart City technologies
**Natural air, land, water resources, reduction of noise level
Source Compiled by the authors on the basis of the materials Green Patrol (2021) and Federal State Statistics Service (2021)

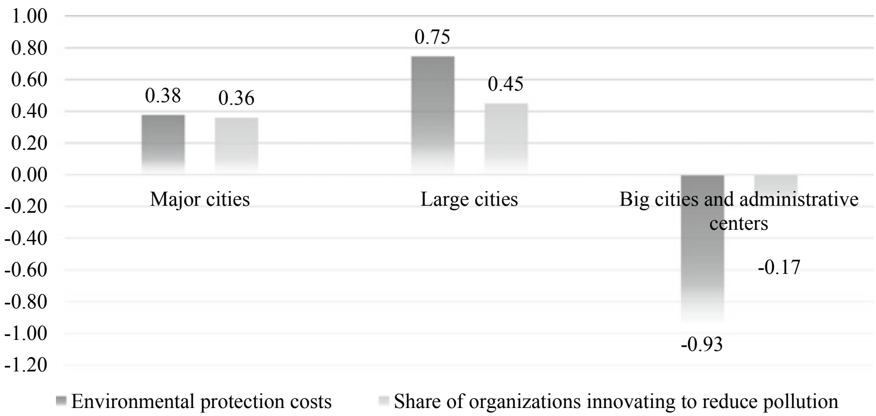

Fig. 2 Correlation of climate change outcomes with funding from different sources, % (*Source* Calculated and built by the authors)

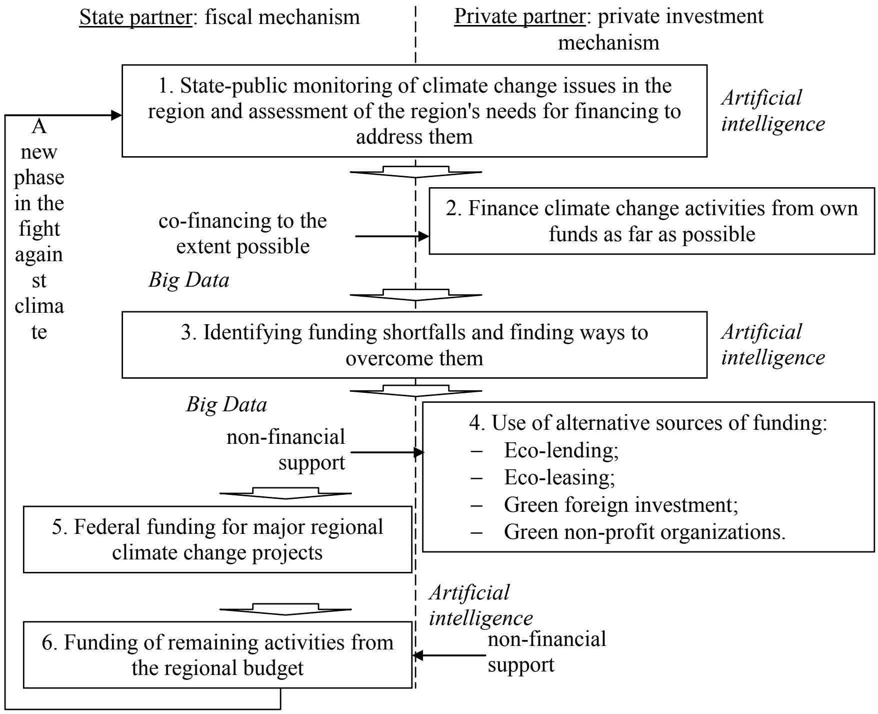

Fig. 3 Smart Region Climate Finance Model for Security through Public–Private Partnerships (*Source* Developed and compiled by the authors)

The model presented in Fig. 3 shows the sequence of different available sources of climate finance, as well as the smart technologies used in the region. At the first stage, together with a public and private partner, state-public monitoring of climate change problems in the region is carried out and the needs of the region for financing their solution are assessed using artificial intelligence—state AI at the level of the region as a whole and entrepreneurial AI at the level of individual enterprises.

The second stage is the financing of climate change activities from private organizations’ own funds, as far as possible (depending on the availability of financial resources), with public co-financing as far as possible (depending on the region’s budget policy). Private and public opportunities are analyzed through the Big Data, which allows the determination of the total amount of climate finance in the region.

At the third stage, both partners jointly determine the funding deficit and search for sources to overcome it using artificial intelligence, which allows you to quickly solve complex optimization problems. The fourth stage is the use of alternative sources of financing: eco-lending, eco-leasing, green foreign investments and green non-profit organizations. It also uses Big Data to comprehensively capture funding from all sources. The fifth stage is associated with federal financing of large regional projects to combat climate change, and the sixth—with financing of other activities from the budget of the region, for the allocation of funds from which artificial intelligence is used.

5 Conclusion

Therefore, a model for financing climate change in a smart region for security has been developed, based on a public–private partnership, the benefits of which are, firstly, the gradual transfer of the burden from private business to the state with maximum savings in the regional budget. Secondly, the simultaneous use of both the fiscal and private-investment mechanisms with the cooperation (partnership) of public administration bodies in the region and regional entrepreneurship. Third, taking advantage of the smart region's capabilities to best identify the region's needs for climate finance and to identify the best sources of financing for climate finance at each stage of the model.

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Industry Specifics and Opportunities to Combat Climate Change in the Economy of the Future in the Context of Industry 4.0

The Creation of "Green" Investment Banks in the Context of Fourth Industrial Revolution

Alexey V. Mikhailov

1 Introduction

"Green" finance is the investment flows used to move towards green economic development. In addition, "green" finance contributes to the modernization and qualitative modification in numerous industries. These changes involve the introduction of new targets for products and processes within the medium term, against the backdrop of new rules and technology capabilities.

For the Russian economy, this trend has negative consequences, because if technologies, products, services do not meet the set goals and requirements, they lose the chance to enter foreign markets and cannot compete with foreign counterparts in the Russian market. Thus, unless timely and acceptable actions are taken, Russia can face a significant increase in technological and intellectual lagging and, as a consequence, economic and geopolitical.

At the same time, targeted "green" financing of individual industries has led to significant technological progress in such industries, as well as contributed to the development of breakthrough advanced technologies, which ultimately led to a significant price shift in economies.

Significant financial flows aimed at the development of renewable energy have led to the circumstance which disappeared the need for a strict linking of production to fossil energy sources. This, in turn, has led to serious positive

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changes (equalization) in regional economic and social development. Moreover, the development of renewable energy sources has contributed to the fact that today companies are no longer interested in the production of energy, but in the search for effective financial models for its transportation and storage.

Such positive changes are required for the Russian economy as well. Targeted "green" financing is necessary to redirect investment flows from traditional industries, which remain important and significant, but, nevertheless, are losing their relevance against the background of the development of advanced digital and innovative industries with high science intensity and significant added value.

Thus, taking into account all the direct financial effects, positive production and sectoral dynamics, social and environmental improvements of economic entities and their environment, budgetary effect and technological transformations, the economic efficiency of "green" investments is a very significant value.

2 Methodology

The "green" finance market is a fast growing and promising segment of the global financial market. As on the middle of 2020, the "green" bonds market amounts to \$125 billion and the entire market for climate bonds amounts to more than \$29 billion (Climate Bonds Initiative 2020). On the middle of 2017, bank "green" loans and government funding were about \$1–1.5 trillion (G20 Green Finance Study Group 2016). At the same period, more than 400 institutional investors, who manage more than \$25 trillion, adhere to the principles of low-carbon investment, and 1.5 thousand members of the UN Principles for Responsible Investment (UN PRI) initiative manage asset in the amount of over \$62 trillion (Principles for Responsible Investment 2020).

At the same time, according to the forecast of Standard & Poor's (S&P), the transition to a cleaner low-carbon economy (which also includes the sector of "green" finance) may take 15 years and require \$16.5 trillion, or \$1.1 trillion on average per year (S&P Global Ratings 2016).

Based on this estimates, net of the reduced investment in fossil-fueled thermal power plants due to "green" investments and savings thanks to the construction of more compact cities (in the amount of \$5.7 trillion and \$3.4 trillion, respectively), the net additional "green" investments in the period 2015–2030 will amount to \$4.4 trillion or \$275 trillion in average annual terms. Over the same period, basic investment in infrastructure (excluding the climatic factor) is assumed to be \$89 trillion, or about \$6 trillion on average per year (The Global Commission on the Economy and Climate 2014).

All economic agents actively use "green" financing instruments, and they diversificate not only the portfolios of "green" projects, but also the utilized instruments in order to reduce risks.

The presence of a third party is very important in the "green" finance market, this concerns appraisers who verify that a financial product (loan or security) belongs to "green" instruments. Currently, there are several major players on the environmental expert market—CICERO (Center for International Climate and Environmental Research, Oslo), Vigeo (Paris) and DNV (DNV-GL, Oslo). But today both the Big Four consulting companies—PricewaterhouseCoopers, Deloitte Touche Tohmatsu, Ernst & Young and KPMG, and international rating companies - Standard & Poor's, Moody's and Fitch Ratings—are actively starting to take participation in this market.

At the same time, there are good examples of the national ranking of "green" projects. Thus, in China, the "green" verification system is based on the methodology developed by the national rating agencies. The People's Bank of China has certified 8 organizations that have received the right to assess the compliance of debt securities with the established requirements for solid bonds. Today quarterly disclosure of information on the actual directions of spending of funds by the issuer and their compliance with those stated in the prospectus has become mandatory, the information is certified by one of that eight certified organizations.

In addition, a distinctive feature of the "green" finance market is the absence of a single unified system of rules and standards up to now. There are several basic documents on the basis of which many countries and companies build their "green" policy:

- Green Bonds Principles (GBP) voluntary guidelines for issuing "green" bonds (issued in 2014 under the leadership of the International Capital Market Association (ICMA).
- Climate Bonds Standard was developed by the Non-credit financial organization Climate Bonds Initiative (CBI) and has a broader interpretation of "green" projects and a clearer industry focus. At the national level, many countries use the national taxonomy CBS.
- The OECD Handbook for Appraisal of Environmental Projects Financed from Public Funds, which offers a set of management tools and approaches to developing public "green" finance programs, as well as the selection and financing of the most cost-effective "green" projects supported by public funds.
- Guidelines for issuing green bonds by the People's Bank of China. The People's Bank of China issued Instruction No. 39 on December 22, 2015, regulating the issuance of "green" bonds. At the same time, the Green Finance Committee of the China Association of Banks and Finance released a catalog of approved "green" projects, which, in particular, provided a classification of "green" projects. Six categories and 31 subcategories of projects were identified, for the implementation of which it was allowed to issue "green" bonds.

In addition, the Financial Stability Board, at the request of the G20 leaders, established a Task Force on Climate-related Financial Disclosures to enable markets to better assess, evaluate and manage climate-related risks. Its purpose is to promote voluntary, consistent, comparable, reliable and clear disclosure of climate-related financial risks. Access to better quality information will enable market participants to better understand and manage these risks. And an early understanding of the issues can, in turn, facilitate a smooth, orderly market transition towards a low-carbon economy (OECD 2017).

Important work towards unification is also being carried out by the G20 Green Finance Study Group. Within its framework, today China and EU, without the participation of Russia and the United States, agree to create their own rules in this market. In fact, these negotiations determine which equipment and which technologies will receive priority funding and be legally subsidized, bypassing the WTO rules.

3 Results

According to the above analysis, the most accessible instrument for financing projects is investment bank financing. Banking instruments are well studied and known to the market, and also flexible in the choice of terms and interest rates, quite liquid and multifunctional in terms of the choice of projects.

In world practice, the banking sector has a very strong position in "green" finance. Citi planned to increase its portfolio of "green" projects to $100 billion by 2020, but the goal was completed last year. Its new strategy includes a $250 billion Environmental Finance Goal to finance and facilitate climate solutions globally (Citigroup Inc. 2020). European Bank for Reconstruction and Development planned to increase the share of "green" projects in the portfolio to 40% by the same date, however, EBRD "green" economy finance hit 46% cent record in 2019 (Bennett 2020). One of the key indicators of management efficiency of Inter-American Development Bank is the share of "green" projects at the level of at least 20% (usually, at the end of the year, this share is 25–30%). New Development Bank and Asian Infrastructure Investment Bank announced the priority of financing "green" projects (Sagorika 2020).

In 2015, 104 banks of the United States issued loans for renewable energy projects, it is 50% more than in 2013. At the same time, not only the total number of credit institutions increased, but also the role of large banks. If in 2014 loans in the amount of more than $1 billion were provided by 12 banks, then in 2015 their number increased to 20, and in the future, a further increase is expected.

In 2010, in order to popularize the initiative in the banking sector, UNEP (United Nations Environment Programme) created a special Banking Commission. At present, many commercial and investment banks, regardless of their membership in the UNEP Banking Commission, develop and use in practice the principles of sustainable development, responsible financing and corporate social responsibility.

In July 2017, 11 major banks around the world (ANZ, Barclays, Bradesco, Citi, Itaú, National Australia Bank, Royal Bank of Canada, Santander, Standard Chartered, TD Bank Group и UBS), with total assets of over $7 trillion, committed to developing analytical tools and metrics to improve project appraisal and disclosure practices on "green" finance risks.

In Russia, the banking sector is more developed than the stock market. The main liquidity is concentrated in the banking sector, there are large players and a wide branch network, the expert and technological level of the banking sector is much higher than in other sectors of the financial market. In addition, the prudential supervision and risk management system in the banking sector is better and more precise than in other sectors.

One of the priorities of the state economic policy is the formation of a competitive Russian banking sector that can develop on its own basis and be an effective tool for ensuring sustainable economic growth. Taking this into account, the most effective and strategically correct step in the development of "green" financing system in Russia is the creation of a specialized banking institution, the main task of which will be targeted investment in "green" projects (Tian 2018).

It is also important that, according to the Russian Ministry of Natural Resources, although "green" bonds are the most effective mechanism for attracting financing for the modernization of equipment and technologies, the key element in the concept of transition to a "green" economy is the creation of a specialized "green" investment bank (Working group on responsible financing 2018).

The "green" bank should have a full (100%) state participation, as this approach can solve the number of tasks. For example, such bank will have a sovereign level of risk in international practice, which will make it possible to receive loans in international markets at a rate for sovereign borrowers. Moreover, the state bank is the most preferred counterparty for foreign investors and partners.

At the first stage, in order to resolve administrative and economic issues and start operating, it is planned to allocate a state subsidy to contribute to the authorized capital of the bank in the amount of 50–70 billion rubles. Further activities of the "green" bank are carried out by attracting borrowed funds in the Russian and international capital markets, performing the functions of a company-operator of public funds, as well as providing non-financial services.

The issuance of "green" bonds is the optimal and most efficient way to attract financing to expand the bank's activities. In fact, "green" bonds are standard corporate debt securities, the proceeds of which are used to finance "green" projects, and reporting on which requires wider disclosure of information.

"Green" bonds as a type of securities are the most well-known universal and transparent financial instrument with clear risk-return parameters, which is applied by all participants in all financial markets and has the maximum number of potential issuers and investors.

At the initial stage of operation, raising funds by issuing "green" bonds is the most preferable, since such securities are actively purchased by international institutional investors and development institutions, the main providers of long-term money, which are most in demand in the implementation of "green" projects (Runde et al. 2019).

Attracting foreign investors to Russian "green" projects by selling them "green" bonds of a "green" bank will become a kind of blocker against possible sanctions that may be initiated by foreign partners for political rather than economic reasons. In addition, foreign investors, with a large pool of Russian "green" bonds in their portfolios, will lobby for the abolition of the existing sanctions restrictions in every possible way.

Moreover, a very promising source of funding is attracting funds from international development institutions. The participation of international institutions in projects will increase the quality and attractiveness of projects for other private investors. In addition, it is possible to use lending of the "second" level, i.e. obtaining a loan from development institutions at a low interest rate (LIBOR + 0.5− 4%) with further lending to projects within the country. Even taking into account the margin of the "green" bank for servicing such loans (up to 1%), the final rate for Russian borrowers, nevertheless, will be more attractive than intramarket ones.

In order to stimulate "green" development in the country, it is advisable to lend to the relevant "green" projects at a preferential rate, but this issue entirely depends on both the state's support for the bank and its ability to attract financing in foreign markets.

Nevertheless, the "green" bank will provide a full range of banking and other financial services with a "green" focus:

- "green" lending—standard bank loan products for financing "green" projects;
- "green" investment—a broader understanding of investment. In particular, it is about both direct investments—through the acquisition of "green" financial instruments (shares, promissory notes, etc.), and indirect - through the issuance of guarantees for "green" projects. Guaranteeing loans for "green" projects is supposed mainly for state "green" projects included in the state programs;
- syndicated lending—organizer and participant of large bank syndications in order to finance large-scale "green" projects.

In turn, the specialized "green" investment bank will focus exclusively on "green" investments.

It is possible to use a "green" bank as an operator of state guarantees to guarantee loans for state "green" projects included in state programs.

Thus, the total volume of federal investment funds only under the program of the priority project "Reducing the negative impact on the environment by eliminating accumulated environmental damage and reducing the share of solid municipal waste disposal" is about 15 billion rubles (The Ministry of Natural Resources and Ecology of Russia 2018).

Additional functions of the "green" bank should be its operating as a national "green" think tank.

First of all, this activity is associated with the development of a mechanism for assessing the carbon footprint of investment projects, the social and environmental assessment of projects and the formation of a statistical database on "green" financing. Within the framework of non-financial functions, a "green" bank can carry out the following aspects:

- analysis of "green" projects and assessment of their risks, collection of statistical information on "green" projects and "green" instruments;
- educational functions in the framework of the development of the market for financing and promoting of ideas for "green" development;
- international activities (including within the framework of interaction with international financial institutions and participation in "green" international associations and initiatives).

Despite the fact that "green" investments are profitable and efficient, they, nevertheless, are characterized by increased riskiness, which is explained by both technological and legislative features of their provision. In this regard, it is especially important that the "green" bank, at the root of its creation, has to be a reliable organization from an operational and financial point of view, to which initiators of "green" projects could apply for financing.

The key question in creating a "green" bank system is the choice between creating a new structure "from scratch" or empowering an existing organization with the powers of a "green" bank. The advantages and disadvantages of "green" bank formation models should be considered.

The creation of a new structure is a more risky and costly measure than providing the existing structure with the corresponding functionality. In addition, the creation of a new structure will require significant time costs for solving organizational issues, recruiting personnel, forming and launching business processes, etc. In the context of the rapid creation and development of the market for "green" financing in foreign countries, it is time costs that seem to be the most significant risk of this option for creating a "green" bank.

At the same time, endowing an already existing state financial institution with the status of a "green" bank reduces these risks. In this case, only additional customization of individual business processes directly related to "green" lending should be added.

However, in current conditions, most large state-owned financial companies and corporations are under the EU and US sanctions, and the issue of their removal is not discussed even in the medium term, which means that such state-owned companies cannot operate in foreign markets, attract foreign investors, set up the transfer of "green" technologies, etc., while the development of "green" financing necessarily requires foreign investment (both technological and financial). This disadvantage actually paralyzes the work of state-owned companies and negates the existing advantages. Small state-owned companies that are not on the sanctions lists do not have sufficient financial stability, flexibility and significant amounts of funding.

In addition, the Russian state management has a wealth of positive experience in creating financial structures (Rosselkhozbank, a number of state corporations and funds), which will reduce the time and administrative costs of creating a new structure to a minimum.

An extremely important aspect of the functioning of the "green" bank is its primary focus on "green" projects. The bank's investments in other projects will be allowed only within the framework of strengthening the financial stability.

This approach will reduce the risk of dispersal of funds. In addition, given the modest opportunities for "green" development in the retail sector, it seems advisable to limit the work of a "green" bank only to the corporate lending market.

The "green" bank will develop a specialized methodology for the assessment and selection of "green" projects, which will spell out the main milestones of the bank's targeted investment:

- the ultimate goal of lending is to finance a "green" investment project;
- clear and transparent criteria for the selection of investment projects;
- clear and transparent procedure for selecting investment projects;
- control over the targeted spending of funds;
- creation of a management system for "green" projects;
- close interaction within the structure of the creditor—controller (if any)—recipient of funds.

The bank will disclose information on the procedure it will follow when deciding on the target nature of a particular "green" project.

In addition, the "green" bank should establish a clear procedure for how investments are allocated to the respective categories of "green" projects listed in the information provided on the use of funds.

The analysis will determine and confirm the compliance of the investment with the declared categories of "green" projects. It is also intended to indicate the expected direct and indirect social and environmental effects (for example, in cases when investments anchor current emissions for the future). It appears that such an analysis will be carried out together with a team of environmental experts.

4 Recommendations

A "green" bank should be a constantly evolving structure and ultimately strive to become a single center of competence and centralization of all processes related to "green" finance, within the framework of improving and giving them a new impetus for development.

In the development of further challenges of the "green" bank, it is possible to expand the tasks and capabilities of the bank in the following areas.

1. Expansion of the operational presence of the "green" bank.

   1.1 The creation of a branch network at the initial stage seems to be optional. As the geography of investment projects of the "green" bank expands, it is necessary to resolve the issue of creating additional offices or attracting regional certified managers who will oversee bank projects in a certain region. As a criterion for opening a regional branch, it is possible to establish a minimum threshold for investment by the bank itself.

   1.2 Creation of a specialized subsidiary "green" fund. A "green" fund is usually understood as a mutual fund, equity fund, the funds of which are invested in companies that implement "green" projects and position themselves as socially responsible and use the principles of responsible financing or directly contribute to environmental initiatives. Most of these funds operate in the field of alternative energy, "green" transport, water supply, waste recycling and improving the quality of life.

   Large financial and industrial companies can also capitalize on such a fund. In order to work on international markets, it is advisable that international financial corporations also participate in "green" fund. In the future, it is possible that such a fund will enter budget funds and, accordingly, finance projects from government programs.

   1.3 "Green" bank as a conductor of state support. A "green" bank as a state bank can become an effective mechanism for the implementation of state support for "green" industries, both through the issuance of direct government subsidies and through the formation of a system of subsidizing interest rates on "green" loans.

   Subsidizing interest rates is the most effective tool that can ensure the growth of "green" loans from private banks by 30–40 times (OECD 2014). It is believed that subsidizing interest rates is significantly more effective than providing direct subsidies. Those industries that are supported in the form of subsidized interest rates are developing 2–3 times faster than those who do not use it.

2. Development of other "green" financial instruments.

In order to diversify its own activities, as well as to develop the national market for "green" financing, the "green" bank can develop various "green" financial instruments.

2.1 It seems efficient to create specialized banking programs and products in the "green" bank, within the framework of which "green" projects will be financed on special conditions (reduced rates, subsidies, grant financing, deferred interest payments, etc.).
2.2 Other "green" financial instruments. Participation of a "green" bank and use of its experience for the development of "green" derivatives and other "green" financial instruments (OTC platforms, "green" stock indices, "green" ratings of issuers and investors, "catastrophic" bonds, etc.)

3. Development of non-financial activities.

3.1 Analytical and scientific platform. It is advisable to create a large educational and scientific-analytical center on the basis of the "green" bank for the institutional promotion and implementation of the principles of "green" development.
3.2 The international cooperation. The joint participation of representatives of the "green" bank and government agencies in international expert advisory groups is necessary, as well as active participation in the most important international public events in order to indicate Russia's interest in this issue and establish close cooperation.
3.3 Promotion of "green" finance activities. It is necessary to use the existing infrastructure of economic forums, where the "green" bank can organize relevant sections and round tables for discussing the most important aspects of the development of "green" finance with the aim of promoting both "green" financial mechanisms and "green" projects.

    In addition, within the framework of promoting "green" financing in the professional community, the "green" bank will become a kind of "showcase" which will show why "green" projects are attractive and how they can be financed. For this, an expert comparative assessment of existing "green" and traditional projects (for example, renewable energy and energy efficiency) should be carried out and published in terms of risks to the lender.

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HEIs Network Collaboration on Water Resources for Fostering Innovative Educational Methods

Vitaly Nagornov, Julia Komagaeva, and Marina Kovaleva

1 Introduction

As a study discipline water resources are a complex multi-sectoral subject that includes various economic, technical, environmental, and social aspects. The discipline is also included in a variety of higher education programs outside of water-related studies. The educational approach of the subject requires flexibility in training, broad application of various innovative and informational methods, international communication and academic mobility, as well as intensive cross-border interaction due to geographical peculiarity of water resources issues. Interactive educational methods contribute to the effective acquisition of study materials, better knowledge, and competence of graduates (Yakovleva and Yakovlev 2014). This approach applied to water resources disciplines allows students to get very detailed insights on the subject and practical experience at the lowest possible cost. Experimental and laboratory methods give an opportunity to simulate real-life conditions.

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Water is an acute problem regardless of geographical location. Central Asia and other countries of the Eurasian region experience prominent pressure on water resources and transboundary problems associated with distribution, increasing demands from agriculture, consumption, industry, and urban populations (Guo et al. 2016; OECD 2016).

2 Methodology

The work is focused on four selected universities, Belgrade University in Serbia, Brest State Technical University in Belarus, Kazakh-German University in Kazakhstan, and Kyrgyz National Agrarian University after K.I. Scriabin in Kyrgyzstan. Four countries are members of the Aarhus Centres network. The Centres support the engagement of governments, citizens, and the private sectors in a discussion on environmental challenges. The Aarhus Initiative presumes proper water resources management, which is crucial for sustainable development and conflict prevention (United Nations Economic Commission for Europe 2014). The Aarhus Centers in these countries facilitate the dialogue in decision-making and the participation of various in sustainable development, equitable water resources management at different levels (Aarhus Centers 2017).

The analysis of the selected universities has been verified by quantitative research and well-illustrated by a review of 45 educational programs on water resources and related areas at Russian universities (Nagornov 2020b).

The educational programs have been clustered by common types and divided into three blocks for further analysis. Every educational program in a cluster has the following similar characteristics: a set of disciplines, structure, or educational methods. Thus, the analysis of the educational programs sample helps to identify the main characteristics of an "innovative approach in education". The concept of the "innovative approach in education" considers new and non-widespread educational methods.

Whereupon, selected existing or former networks have been studied for common traits of educational innovations.

3 Results and Discussion

To create a new approach for the development of educational programs on water resources, it is necessary to explore the international experience of networking in using innovative methods in education.

Along with bachelor, master, and doctoral programs, the Belgrade University in Serbia, also offers one specialized distance learning program "Educate! Water resources and environmental management" (Belgrade University 2017). It is an international program organized by four universities in the region of South-Eastern Europe: the Athens Polytechnic University, the University of Belgrade, the Technical University of Bucharest, and the University of Ljubljana. The program aims to increase and expand students' academic competencies in integrated water management systems, water, and environmental policy. The main innovative element of the program is connected to e-learning. Courses are provided to students through a set of easy-to-use, flexible e-learning support tools integrated into the web platform.

The Brest State Technical University of the Republic of Belarus offers water conservancy engineers training that is included in various degree programs (Brest State Technical University 2017). Students build different types of maps, conduct complex studies and calculations. Given the international ambitions of the university, the interregional network cooperation is of crucial importance for increasing the program effectiveness and integrating an innovation component.

In 2011, the Master's program "Integrated Water Resources Management in Central Asia" (IWM MA) was launched in the Kazakh-German University within the framework of the Berlin Process (Kazakh-German University 2017). The Berlin process aimed at supporting water resources management, and transformation of water into a subject of stronger cross-border cooperation has also impacted education in this area (Transboundary Water Management in Central Asia 2017). The university seeks to constantly expand the partners network throughout Central Asia and beyond and it is open to potential cooperation initiatives as well.

The training of specialists in 'Environmental Engineering and water use' at Kyrgyz National Agrarian University after K. I. Scriabin is conducted on various programs and provides a remote form of training to obtain a bachelor degree (Kyrgyz National Agrarian University 2017). The university has advanced networking experience with international programs and universities, which is a solid advantage for elaborating new educational approaches.

The educational programs on water resources and related areas at Russian universities could be formally split into three blocks (Fig. 1).

The first block consists of programs that are based on the concepts established during the times of the USSR. The share of this block is not large (11%), but it sufficiently illustrates the lack of flexibility in developing the curriculum.

The second block is focused on compliance with the standards adopted by the Ministry of Education and Science, assumes a unified approach to naming programs related to water resources. This blog is the largest one (73%), but quantitative measurement does not suggest introducing additional subjects and new training technologies. Programs titled 'Environmental Engineering and Water' comprise more than half the sample.

The third block includes various modifications of standard educational programs (16%), which can imply an innovative educational approach, at least in this quantitative context. The third clustered block is considered as innovative.

To find common traits of educational innovations, it is essential to explore international networking experience in using innovative educational methods.

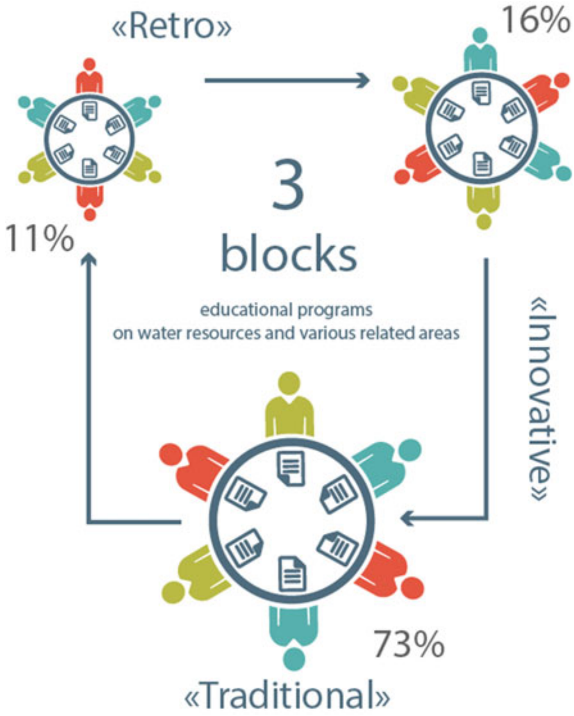

Fig. 1 Sample of Russian universities, representing 45 educational programs on water resources and various related areas (Nagornov 2020b)

Networks established as regional projects have demonstrated greater productivity and efficiency. For instance, the Academic Information and Communication Network in Russia, implemented under the auspices of Tempus, enabled many universities to try serving as network nodes to address the lack of knowledge on water resources. The external collaboration window of the Erasmus Mundus project by Jeanne Monet facilitated the development of academic mobility (European Commission 2010). HEIs also implemented an innovative component on integrated management of transboundary water resources and developed a system of continuous water management education in a synergistic universities network (Network of EECCA Water Management Organisations 2010).

The network interaction on the basis of the Eurasian Center for Food Security (ECFS) at Moscow State University is a specific example. The Center manages a development program of information support system for education in the field of food security, sustainable land use, and protection of land and water resources. The ECFS developed a concept of creating an information system to provide information support for international projects on integrated educational and scientific activities, including water resources. The main goal of this activity is to build up the scientific intellectual potential and increase professional capacity of specialists in the Eurasian region. To fulfill this platform's objectives, several solutions were introduced to incorporate progressive, innovative educational technologies into farming education and provide consultations on increasing effectiveness of the latest information and training products that are consistent with the modern development strategy (Eurasian Center for Food Security 2020).

Educational programs in water resources are always in focus. For example, the Organisation for Economic Co-operation and Development (OECD) proposes to promote education and various trainings for water experts to enhance the capacities of water institutions and organisations, and decision-makers to foster cross-border cooperation (OECD 2015). Some OECD countries apply requirements to use information technologies in the educational process that are mandatory for all institutions working in the industry, including water resources. The relevant requirements are set out in the standards and applied to the information use by students, and the ways of organizing and administering the learning process.

The qualitative difference in water resources programs assumes availability of short practical distance courses on introducing effective and innovative methods, courses for decision-makers and stakeholders, training courses on expanding the service sector for independent experts, and courses for teachers.

The innovative educational approach demonstrates effectiveness when it is integrated into a program on water resources. Instead of a standardized lesson, teachers switch to laboratory observations and experimental work. Teachers and students use an interactive whiteboard to conduct experiments following the steps of a scientific process such as a hypothesis proposal, data collection, analysis, and assessment of information on the water cycle (Mott et al. 2010).

Technology increases students' motivation and interest to make traditional training more interactive. The inclusion of interactive teaching methods is also a powerful evaluation tool. Students' questions about water systems can be addressed either in an interactive form or during a practical seminar. Augmented reality immersive courses on water resources could become drivers for the development of innovative educational programs.

For example, Nazarbayev University has experience in creating information database (Sagintayev and Kerimkulov 2017). Universities and individual researchers also have access to the Central Asian water and energy data portal created by the World Bank, which accumulates data from global open sources and provides tools for visualization of spatial and temporal data based on cartographic information (Central Asian water and energy data portal 2020). The databases and tools can be embedded in the educational process to provide a more practical training perspective.

A positive experience of HEIs networking on water resources relates to the creation of a community of key HEIs in Central Asia. Such Central Asian academic network (Fig. 2) (Central Asia Knowledge Network 2020) was established in 2012 by the World Bank in partnership with the Regional Environmental Center for Central Asia (CAREC) (World Bank 2017). The

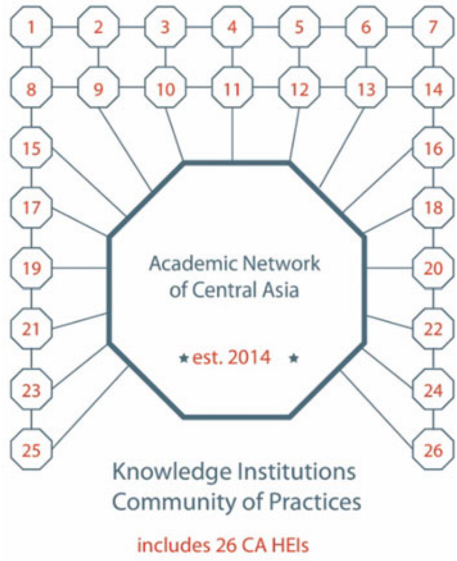

Fig. 2 Academic Network of Central Asia (Nagornov 2020a)

network brings together representatives of 26 HEIs in Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan, who regularly exchange knowledge and experience through seminars, research, exchange programs, fieldwork, and academic events. In 2019, the Network's experts, led by S. R. Ibatullin, prepared a 'Review of the scientific, educational and research potential in the water sector of higher educational institutions in Central Asia', which was followed by the development and expert review of 17 unified curricula of disciplines in two key bachelor's level specialties in the field of water resources in June 2020 (World Bank 2019).

The coronavirus pandemic in 2020 and the associated transition to distance learning posed new challenges for HEIs, both concerning teaching and strengthening interaction with partner institutions to exchange knowledge and experience on the introduction of remote work formats and online educational materials development. In this regard, the role of existing mechanisms for interaction between HEIs within the knowledge networks becomes even more relevant. The projects, such as CAREN, aimed at increasing the potential of the telecommunications of Central Asian countries, can provide the necessary technical support and connection speed for the academic communities of Central Asia (CAREN 2017). The successful interaction experience among Central Asian HEIs within the virtual network proves the effectiveness of using online platforms to increase network interaction on water resources at the regional level. The academic network of Central Asia cooperates closely with the Central Asian Journal of Water Research (CAJWR 2020). According to CAREC, 'joint publications and training are the main important aspects of academic knowledge exchange' (Abdullaev 2015).

4 Conclusions and Recommendations

The review of existing programs of higher educational institutions and networks has identified advantages for promoting innovative educational approaches in the area of water resources, and highlighted the need for transboundary cooperation through establishment of regional networks with higher educational institutions as members.

Central Asian HEIs are looking for networking cooperation. In particular, Central Asian experts in higher education are planning to develop a unified curriculum for all regional water specialists. Also, HEIs are interested in water specialists who can work in different international networks. The definition of a target audience, products, and knowledge dissemination is the priority. The modular nature of programs and interactive elements that enable teachers to interact with the audience, together with the knowledge management infrastructure will help enhance comprehension of the learning materials.

Based on the assessment of the existing network approach in water resources education and of emerging needs for the transition to online communication formats, the proposed solution for higher education institutions could be based on (1) the creation of sectorial professional networks and online platforms; (2) the possibility to create unified learning curricula that could be accepted by members of a HEIs network.

Networking fosters cross-collaboration of HEIs, minimizes costs, creates a solid base for efficient regional cooperation and dialogue on regional water resource issues. As an integrated study discipline, water education has to meet high-quality standards, use new educational mechanisms and enhance opportunities for regional cooperation.

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Sustainable Development of the Oil and Gas Industry and Modern Challenges of Decarbonization

Igbal A. Guliyev, Vladislav I. Kiselev, and Victor V. Sorokin

1 Introduction

1.1 What Is Sustainable Development?

Sustainable development implies economic and social changes whereby natural resources, investments, scientific and technological development, personal development and institutional change are coordinated with each other and strengthen the current and future potential to meet human needs and aspirations (Fig. 1). The Sustainable Development Scenario (SDS) implies a major transformation of the global energy system, showing how the world can transform to achieve the Sustainable Development Goals (SDGs). The key SDGs are presented in the form of a diagram (Fig. 2) (Mire et al. 2018).

The sustainable development scenario assumes an ambitious and pragmatic vision of how the global energy sector should evolve to achieve energy-related SDGs. This scenario is inherently solving the inverse problem, starting with the vision of the end result (SDGs), and then finding what is needed to achieve the goals in a realistic and cost-effective way.

This paper focuses on the environmental aspect of sustainable development policies applicable to the oil and gas industry.

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Fig. 1 Methane emissions according to the International Energy Agency (World Energy Outlook 2020)

1.2 How Can We Meet Energy Demand in the Near Future?

As mentioned above, experts predict an increase in world energy consumption. However, despite the global trends of transition to renewable energy sources the cost of these types of energy and technologies today exceed that of traditional fuels. Therefore in the medium term gas may again be in demand as a transitional fuel that will facilitate the stable use of renewable energy sources in the future.

To meet global energy demand Russia needs to develop new mineral-rich regions. The Arctic can become one, since it possesses abundant oil and gas resources (Fig. 3). Russia's growing interest lies in the development of oil and gas fields located on the Arctic shelf.

Operational activity in the Arctic requires increased attention to the environmental aspect of doing business, since potential environmental disasters can disrupt the natural balance in the whole region. Therefore, compliance of business enterprises with the sustainable development policy becomes even more relevant in the Arctic context.

2 Materials and Methods

Adapting to a new vision of the world energy future remains a challenge for the oil and gas industry. This could be due to production of "alternative gases" such as biomethane and low carbon hydrogen, as well as use of technologies such as carbon capture and utilization (CCU).

Fig. 2 Key SDGs for the oil and gas industry (Mire et al. 2018)

Representatives of “Gazprom” maintain that it is necessary to develop hydrogen energy now with an eye to the future. According to Gazprom’s calculations, the decarbonization of hydrogen will reduce the volume of subsidies for renewable energy sources, which in Germany alone has grown fivefold over the past five years—from €4 billion to €20 billion per year (Kutuzova 2019). Thus, decarbonization technologies will allow the oil and gas sector to successfully compete with renewable energy sources, both in terms of energy production as well as by minimizing the negative environmental impact.

One optimal solution to the problem of decarbonizing the industry and generating more energy carriers could be the production of hydrogen and low-carbon hydrogen directly on the Arctic shelf.

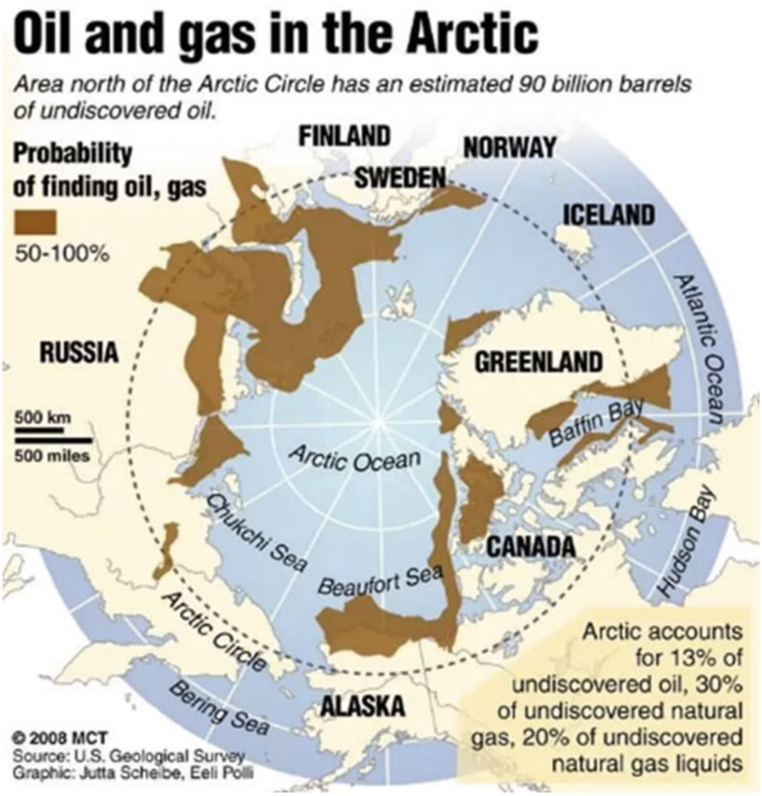

Fig. 3 Prospects for the Arctic as an oil and gas producing region (USGS/Creative Commons)

Several options for producing and storing hydrogen are worth considering to create new offshore capacities (Pearson et al. 2019).

- Low carbon solutions include methods for producing hydrogen with reduced carbon emissions or those with carbon capture and utilization (CCU).
- Zero carbon solutions include methods for producing hydrogen from green or carbon-free sources.

Potential way of hydrogen production in the offshore environment is represented below (Fig. 4).

There are several possible solutions related to offshore hydrogen production. They include both new avenues, such as creating graphene and hydrogen from methane, and traditional technologies for processing methane.

Production of hydrogen and graphene from methane. A new approach to hydrogen production was developed by “Cambridge Nanosystems”. It uses

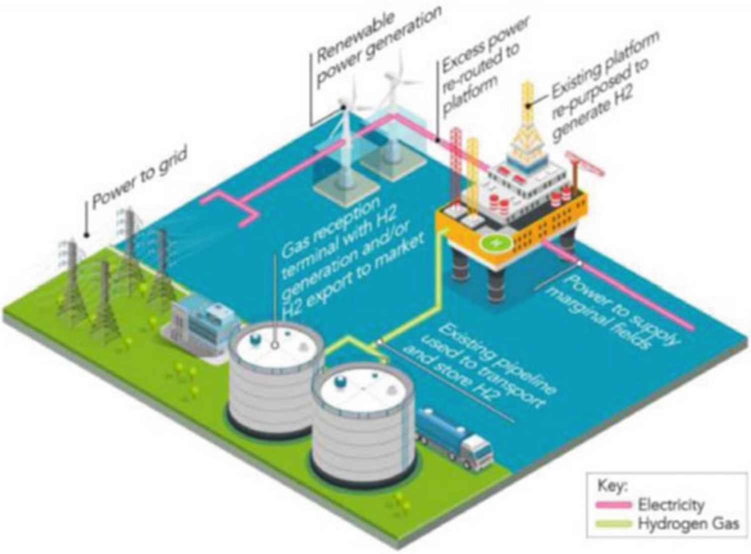

Fig. 4 Potential Offshore Hydrogen Production Scheme (Pearson et al. 2019)

methane as a feedstock and uses microwave plasma to produce hydrogen and high-quality graphene. The technology is currently being tested and a working prototype has been developed.

Steam methane reforming. The industrial scale steam reforming of methane is well-understood. Two methane reforming technologies are currently being considered as solutions for producing hydrogen offshore: modular steam methane reforming (SMR) and auto thermal reforming (ATR). In SMR methane reacts with steam in the presence of a catalyst at a temperature of 750–900°C with the formation of synthesis gas (synthesis gas of a mixture of H_2 and CO). The steam reforming reaction then converts the synthesis gas to H_2 and CO_2. The quality of hydrogen after the SMR process is about 75%. Additional processing will help to further purify it up to 99.9%. The process flow diagram is shown in Fig. 5.

2.1 Carbon Capture, Utilization and Storage (CCU)

CO_2 capture and utilization (CCU) is currently regarded as one of the possible solutions to reduce the concentration of CO_2 in the atmosphere.

There are various methods and technologies available today that are used to separate CO_2 either from natural gas or flue gases (from a power plant). The method of separating CO_2 in each specific case depends on the conditions of extraction, transportation and processing of gas, as well as the amount and composition of the gas mixture. As easy as it may seem at first glance, choosing the best technology can be a problem due to a number of factors,

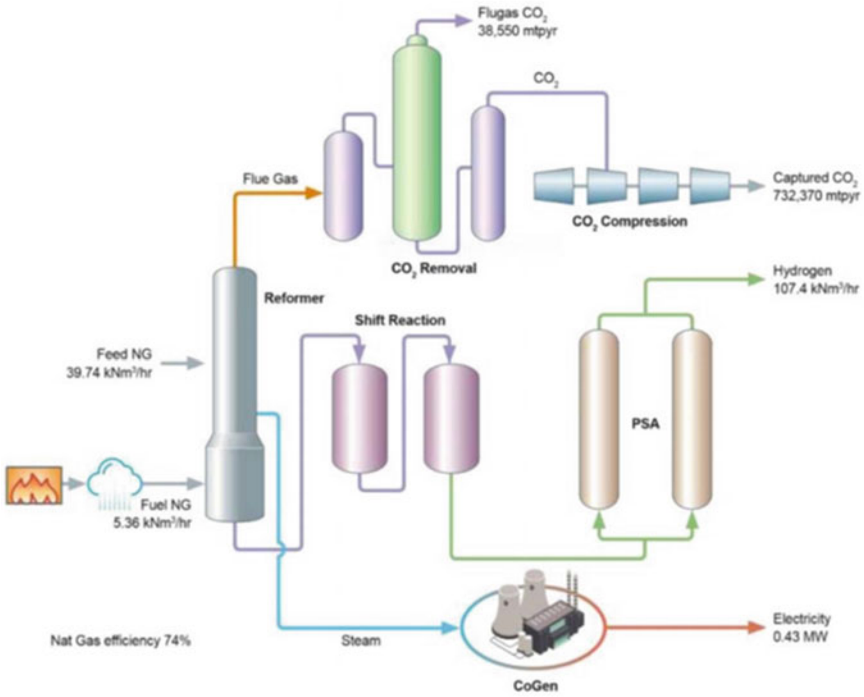

Fig. 5 Steam methane reforming (Pearson et al. 2019)

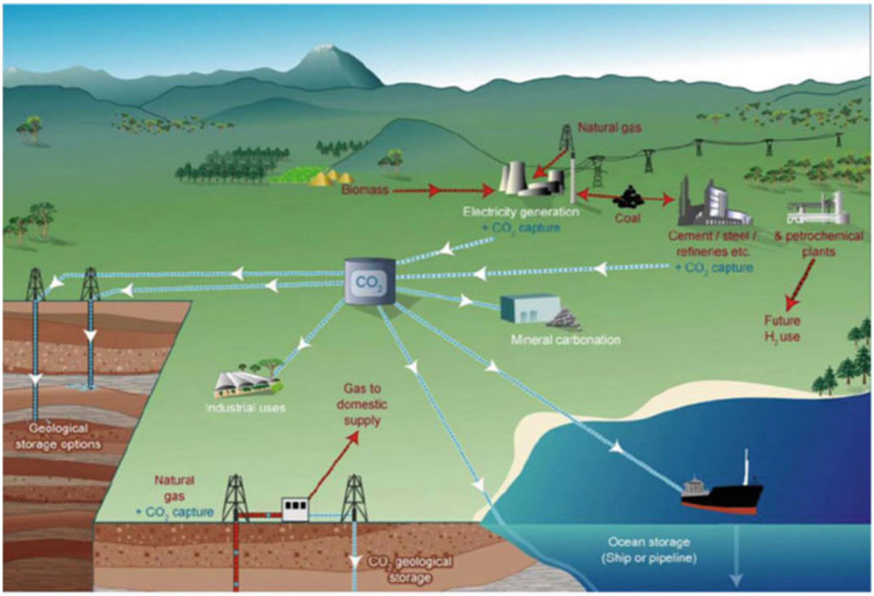

Fig. 6 CO_2 capture and utilization flow (Agiaye and Othman 2015) since no technology can perfectly match all the conditions required for separation. Therefore, each of them has its own advantages and disadvantages. Factors influencing the choice of technology include:

- CO_2 content in commercial gas;
- Presence and concentration of other impurities in raw gas such as H_2S and water content;
- Presence and concentration of heavy hydrocarbon components, pollutants and water vapour.

The following CO_2 separation technologies are currently available (Agiaye and Othman 2015) (Fig. 6):

- **Absorption**. Includes absorption by diffusion in liquid or solid absorption media (e.g. amine absorption of CO_2).
- **Adsorption**. The gas component to be separated reacts with the surface of a solid adsorbent such as activated carbon, silica gel, zeolites and fine platinum.
- **Separation of components** using the principle of solubility—diffusion to penetrate the membrane.
- **Chemical conversion to another compound**—for example, steam reforming of natural gas to produce H_2 and CO_2.
- **Phase creation by heat transfer.** Includes the use of phenomena such as condensation, desublimation, or distillation.

3 Results

Thus, if the world economy adopts a sustainable development policy one can expect a sharp reduction in CO_2 emissions and an improvement of the environment. There are technologies to reduce the amount of carbon in the atmosphere and in the near future we can expect more and more advanced and effective options.

4 Conclusion

Adoption of sustainable development policies including the use of decarbonization technologies may not only reduce CO_2 emissions to the atmosphere, but also enable successful continuation of business and explorational activity in new territories, especially the Arctic shelf.

Russia as a major player in the global energy sector should show interest in decarbonization technologies promptly in order to maintain a leading position in the new economy of the future.

The deterioration of the ecological situation in the world is known to worsen every year. If measures are not taken in time the world may be on the brink of a global environmental disaster. Leading countries and large companies should be the first to identify new directions of politics and economics aimed at combating negative factors.

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Ecological Vector of Social Responsibility in Energy Companies

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1 Introduction

Global activities of energy companies increase the potential of global environmental disaster. The pollution and depletion of natural resources caused by their business activities have been sound as an alarm by international organizations and scientific community. the world community and the governments of different countries pay special attention to the preservation of the environment and the implementation of social aspects of business. A variety of international codes provide guidelines and recommendations for the best practices. These international codes often times shape the national laws that guide business activities of the energy companies. The main purpose of all these documents is to introduce uniform standards in international economic and business relations (Dementieva 2010). These rules are voluntary but any national organization which expresses its solidarity with these principles has obligations to comply with these standards. Such practice not only significantly increases the responsibility of companies towards stakeholders, but also introduces ethical frameworks for business activities and operations, which helps to minimize unfair competition.

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The main aim of the article is to identify the relationship between the concept of sustainable development and the social responsibility of large business, primarily energy, as well as to present the analysis of the best practices of fuel and energy sector in this sphere. The paper reveals the essence and content of the concepts of corporate social responsibility and sustainable development as the basis of the strategy of modern companies, especially in terms of solving ecological problems. It also analyzes ways to preserve the planet's ecosystem, at least in the form in which it currently exists. The final part of the article contains conclusions about the significant mutual influence and interdependence of the concepts of social and ethical marketing and sustainable development, which must be taken into account by a business, regardless of its size, when developing long-term plans.

2 Methodology

The study of the impact of environmental pollution problems on the ecology of our planet in the context of the development of modern industrial production (industry 4.0) is based on the use of general logical research methods such as analysis, synthesis and analogy, as well as methods of cognition of the empirical level, which include observation, description, measurement, interview, experiment, simulation and etc. The basis of the study is the relationship between the concepts of sustainable development and corporate social responsibility, as well as to related issues, is the dialectical method, which recommends working on the following principles: when conducting research, take into account the laws of dialectics; describe phenomena based on philosophical categories; refer to the object of research as an objective reality; systematically describe the considered factors and phenomena associated with the studied object; check the acquired new knowledge in practice. When writing this article, the listed principles and methods were used.

3 Results

3.1 The Main Aspects of Social and Ethical Marketing

Marketing as economic activity strives to balance the economic interests of the manufacturer and the consumer. In modern conditions, environmental protection as a part of business ethics now is an integral part of the marketing management concept of the company. Codes of ethical conduct and corporate ethics are adopted at the company level, managers develop special social programs. To increase competitiveness in the market place large companies tend to demonstrate and emphasize their socially responsible behavior.

Thus, the development of these processes led to the emergence of a new trend—social and ethical marketing. This concept is based on the combination of interests of all stakeholders and takes into account environmental standards and ethical norms. It is aimed at the optimal solution of the environmental, economic problems and long-term interests of the whole society. So, the emergence of socially ethical marketing concept is related to a shortage of natural resources, environmental degradation, rapid population growth and an unsatisfactory state of the social business policy.

World energy consumption is growing every year. While traditional sources of energy extraction and production are becoming more efficient, the growth of the world's population and the emergence of new energy-intensive industries are increasing overall energy consumption. In 2015, world energy consumption amounted to 20.76 trillion kWh, according to the International Energy Agency, the forecast for 2030 is 33.4 trillion kWh, and by 2050—up to 41.3 trillion kWh.[1]

Socio-ethical marketing concept has two main aspects:

- Social, which means the improvement the well-being of the poorest strata of the world population and the implementation of measures to meet social needs;
- Ecological, which means that modern business stands for the protection of the environment by minimizing pollution and creating quality environmentally friendly products.

3.2 Pollution of the Earth's Ecosystem by Energy Companies

Traditional energy sources—oil, gas, coal, and to a large extent nuclear power—are the most significant sources of environmental pollution in the world. The primary negative impact of the oil and gas industry becomes noticeable even before the actual resource extraction begins. For example, seismic exploration for the search for oil and gas deposits involves the excitation of elastic waves into the earth's strata—this is due to explosions of TNT at a depth of about twenty meters underground. These actions have an irreversible impact on the ecosystems of the explored territories.

After oil production with the help of reservoir waters (primary production), it becomes impossible for further oil recovery, operations to maintain pressure within the strata are necessary. Foreign liquids used for this, such as oil-field brine, lead to the pollution of reservoir water resources. In addition, it is not uncommon to use fresh interstitial water to maintain pressure within the strata, which is initially suitable for drinking and may have an outlet to the surface in other places. It takes time to restore ecosystems, and if oil production is carried out in permafrost areas, then in such conditions, the regeneration of soil and groundwater is even slower. Petroleum resources are extracted mainly in two ways, called "open" and "borehole". The first involves above-ground operations, when oil lies close to the surface. In this case, the excavation of the earth's strata leads to the complete destruction of the adjacent ecosystems,

[1] Alternative energy (Russia and the world) https://www.tadviser.ru/index.php.

completely transforming the landscape of the area. Underground oil production methods are less detrimental to natural systems and are more widespread, because most of the hydrocarbon resources lie at a decent depth. However, such methods always result in disturbances in the composition and properties of rocks, which take a lot of time to restore to their former appearance.

But exploration work and primary production of hydrocarbons are only "primary natural and anthropogenic processes". While they are devastating to the environment—polluting topsoil and groundwater, transforming landforms and polluting the air—they are only the initial stage of the activities of energy companies. Further, long-term exploitation of the field, then the transportation of hydrocarbons and their further processing—the so-called "secondary natural-anthropogenic processes" takes place. The exploitation of the field incites much more harmful processes in the lithosphere, both for the flora and fauna, and for humans, namely, collapses, sinkholes and earthquakes. The associated gas generated during oil production emits a huge amount of harmful chemicals (hydrogen sulfide, nitrogen oxides, etc.), which make up the lion's share of all greenhouse gases. However, the aforementioned anthropogenic changes in ecological systems cannot be compared with accidents that occur at production stations in terms of the impact on nature.

Accidents at oil production facilities are not a frequent occurrence, but their consequences are so destructive that in terms of the impact on nature and humans, they can be second only to disasters at nuclear power plants. After oil production, which in most cases does not end with an environmental disaster, energy companies will have to transport resources.

Oil and gas resources are transported in two ways—by pipeline (gas pipeline or oil pipeline) and by tanker transportation (if we talk about gas, then tanker transportation is a way of transporting LNG—liquefied natural gas). At the same time, environmental problems in the form of destruction of landscape-natural systems and varying grades of soil, air and water pollution, begin from the stages of pipe laying. However, as in the case of the extraction of energy resources, accidents during their transportation are the most destructive factors for nature. Oil spills resulting from pipeline or tanker accidents have the same devastating consequences as accidents at production facilities. The most common cause of pipeline accidents is pipe wall wear.

The stage of processing oil and gas resources also causes irreversible damage to the environment. The activity of oil refineries in terms of the amount of harmful emissions is not much inferior to the coal industry. Every year an average enterprise with a capacity of 1000 MW pollutes the atmosphere with a colossal amount of harmful substances, the list of which includes aldehydes, carbon oxides, sulfur dioxide, etc.

From all the above data, it could be concluded that the oil industry is one of the dirtiest branches of the energy sector, and can be put on a par with coal and nuclear in terms of the negative impact on the environment.

The coal industry in the modern world has given way to other branches of the electric power industry, but some one hundred and fifty years ago, the economy of the whole world was based on coal. The Industrial Revolution was the first step towards environmental pollution, and it was with coal that this pollution began.

As in the case of oil and gas, the coal industry begins to have a negative impact on nature even during the exploration and production stages. Explosions are also widely used here, but big problems are caused by the so-called "waste dumps", which violate the sanitary conditions in the mining region. These dumps are waste, stacked waste rock recovered from coal and shale mining. Basically, this waste rock consists of impurities of coal, limestone, sandstone, mudstone, as well as a number of combustible substances—which is why they are fire hazardous.

Rock dumps occupy areas of fertile land, making it unsuitable for living microorganisms and ecosystems. In addition, they provoke pollution of upper and ground waters, which transfer harmful substances further downstream, thus polluting other ecosystems (as is the case with oil and gas production).

Coal processing, like oil refining, is accompanied by strong emissions of harmful substances into the atmosphere, which makes living near coal processing plants unsafe, both for people and for other natural elements.

A number of studies have shown a direct correlation between the amount of coal processed (i.e., the capacity of the enterprise) and the number of diseases, including cancer, among the population of nearby settlements (Moon et al. 2013).

Nuclear power plants were initially considered the cleanest option for generating energy among all the traditional fuel and energy complex. Indeed, for a while, society believed that the transition to environmentally friendly energy sources would begin with the nuclear power plant. At nuclear power plants, emissions of those harmful substances that accompany oil and gas and coal enterprises are completely absent. By and large, there are no emissions at nuclear power plants as such, because its work is based on the fission of uranium. In addition, unlike the oil and gas and coal industries, nuclear power plants do not use oxygen—it does not play a part in the process of energy production.

The only production disadvantage of this industry is water pollution, since large water resources are needed to cool the turbines. If a nuclear power plant does not have its own reservoir for draining and collecting technical water, they use natural water sources, which ends up with severe pollution of the latter. However, most modern factories have their own artificial reservoirs, and this drawback can no longer be cited in endorsement of the negative impact of nuclear power plants on natural ecosystems (Zverev and Malyshev 2018).

Nuclear power plants are no longer considered environmentally friendly, and their main drawback, unfortunately, became widely known almost half a century ago. The damage caused to the planet and all its inhabitants as a result of accidents at nuclear power plants is hundreds of times greater than the possible benefits of this energy industry.

Currently, large energy companies are forced to spend significant financial resources on the area of corporate social responsibility, since their image which means- their market success, directly depends on this. However, despite the improvements in technologies for exploration, production, transportation and processing of energy resources, industries that work with traditional energy sources still cannot become completely “clean”. Air, water and soil cover pollution, as well as unforeseen (rare, but possible) man-made disasters, one way or another, will always be adjuncts of the electric power industry. Therefore, in future, working with alternative energy sources by energy companies, will be much safer as well as more economical for natural ecosystems and humans.

In this case, the situation can develop in two directions: the creation of new “environmentally friendly” energy companies or an increase in the share of using alternative energy sources with a constant decrease in the production of traditional energy sources by existing companies.

3.3 Alternative Power Engineering

The reserves of traditional hydrocarbons on Earth are not endless, which means that the time will come when modern energy corporations will have nothing to generate energy from. Unlike traditional energy sources, alternative (renewable—RES) are based on renewable raw materials. Sun, wind, water, the warmth of the earth’s interior and debris simply cannot end. At the same time, in the process of generating energy from alternative sources, air, water or soil pollution does not occur, because the principle of energy production is very different from those that are traditionally used.

It cannot be argued that renewable energy sources provide completely harmless energy production, since any human activity mostly affects natural ecosystems negatively, in one way or another. Nevertheless, in terms of environmental damage, alternative energy is hundreds of times inferior to its traditional competitors.

The advantages of Renewable Energy Source include:

- Availability (no need to own oil or gas fields).
- Environmental friendliness (there are no harmful emissions into the environment).
- Savings (the energy produced has a low cost).
- The disadvantages and problems of alternative energy are very significant:
- Construction and maintenance costs (equipment and consumables are expensive). Because of this, the final price of electricity rises, so the main task of the developers is to reduce the cost of installations.
- Low efficiency of installations (except hydroelectric power plants).
- Negative impact on the ecosystem (the demand for biofuels can led to a reduction in acreage for food crops, and etc.).
- Dependence on external factors (the strength of the wind, dependence of solar energy on the geography of the country).

Traditionally, renewable energy sources include water, wind, sun, biofuels, geothermal sources, uranium and various wastes.

Solar energy—the production of electricity and heat by heating the silicon wafers of solar cells (working as semiconductors). In fact, a solar power plant is a technology for the direct conversion of light energy into electricity. It is a fairly common type of renewable energy, as it is available almost anywhere in the world.

Solar power plants do not harm nature in the production of electricity, since there is no by-product in their operation. They also do not require the extraction of raw materials, their source of production is sunlight. Solar energy does not require transportation by pipelines or tanker shipments. Energy is delivered to the consumer via power lines. Accidents at solar plants are not scary either- it only threatens with power interruptions.

At the moment, the efficiency of solar energy is weakened only by factors such as non-sunny weather and strong heating of the batteries. In addition, solar panels need care—the surface needs periodic cleaning (Zhurba and Dyachenko 2017), and the battery itself requires periodic disposal.

Wind power is already a less affordable way to generate electricity. For the stable operation of wind power plants, a permanently blowing wind with a speed of at least 4.5 m/s is required. The principle of operation of these plants is based on the transformation of kinetic energy (wind energy) into mechanical (rotation of the blades of a wind turbine), which is then converted into electricity. Wind power is known for its environmental friendliness, because wind power plants, like solar panels, do not produce a by-product. Accordingly, their work is not accompanied by pollution of natural ecosystems and does not threaten the health and life of the planet. However, wind turbines do not guarantee constant energy production, and their vibration is so strong (especially in large wind parks) that it destroys underground ecosystems. Another disadvantage of wind energy is that bulky power plants spoil the landscape, however, this does not affect the environment in any way.

The principle of operation of hydroelectric power plants is based on the kinetic energy of water, which means that a permanent strong pressure is needed for the operation of hydroelectric power plants. They are usually built on rivers, and the steeper the slope near the river, the more efficient the power plant will be. If there is no natural water pressure, then a dam must be installed for the station to operate. Hydropower is probably the most controversial of the types of alternative energy, since, unlike solar or wind power, it has an effect on natural ecosystems. Using the energy of water, hydroelectric power plants damage the life of river inhabitants. Dam, in turn, hinders the natural migration of fish, which negatively affects their population. In addition, accidents at hydroelectric power plants will not pass without leaving a trace—there is always a risk that the dam will burst; high seismicity is observed in mountainous regions.

Geothermal energy is a kind of alternative energy, the source of production of which is geothermal sources—natural thermal fields. This type of renewable energy is especially popular in Iceland. In bioenergy, the source of production is biomass—plant and animal creatures. Both electricity and heat can be obtained from biomass, as well as fuel (the so-called "biofuel")—bioethanol, biodiesel, etc., which is biodegradable.

Most of the solid biomass- wood and compressed agricultural waste, is used to generate electricity. Energy is generated by combustion—but no harmful chemical elements are released into the air. Therefore, the Paris agreements do not classify bioenergy as a potentially hazardous energy sector. Part of bioenergy is waste recycling—or rather, only that component which refers to the recycling of natural waste.

Energy generated from waste and industrial waste is only partially "green", about 50%. The technology for the production of energy from waste was named abroad—Waste to Energy (WtE).

3.3.1 Renewable Energy in the World

The main consumer of renewable energy sources is the European Union. In some countries, alternative energy generates almost 40% of all electricity. Various support measures have already taken root there: discount rates for connection and refunds for the purchase of equipment. The countries of the East and the USA are not lagging behind.

<u>Germany</u>. 40% of electricity in Germany comes from renewable sources. It is the leader in the number of wind turbines, which generate 20.4% of electricity. The remaining share is accounted for by hydropower, bioenergy and solar energy. The German government has set a plan: to generate 80% of energy from alternative sources by 2050, but does not want to close nuclear power plants yet.

<u>Iceland</u>. Iceland has a lot of hot water because it is located in a zone of volcanic activity. The country provides 85% of homes with geothermal heating and covers 65% of the population's electricity needs. The sources are so powerful that they want to export energy to the UK.

<u>Sweden</u>. After the 1973 oil crisis, the country began looking for alternative sources of energy. It all started with hydroelectric and nuclear power plants. Greenpeace was often criticized because of the Swedish nuclear power plants, but the share of energy from nuclear power plants has not been growing since the late 1980s. Since the 90s, Sweden has been building offshore wind farms in the sea. An additional tax has been introduced on carbon emissions by enterprises into the atmosphere, and there are incentives for producers of wind, solar and bioenergy.

Sweden is also actively using energy from waste processing and even plans to buy it from neighboring countries in order to abandon oil. Some cities get heat from incinerators.

<u>China</u>. In China, the most powerful hydroelectric power station in the world is the Three Gorges. The largest wind resources are also located in China (three quarters of them are delivered to the sea). It houses 2,700 geothermal

sources and produces 63% of solar energy conversion devices. China is the third largest producer of ethanol-based biofuels in the world.

3.3.2 Alternative Energy in Russia

The different geographic location of the regions and the specificity of climatic zones in Russia do not allow the development of this industry evenly. Increased investment in renewable energy and government support is helping many companies do business successfully. Renewable energy types in Russia are the following.

Solar energy. It is used both on an industrial scale and by the local population as a main or backup source of heat and electricity. The total capacity of solar installations is 400 MW, of which the largest are in Samara, Astrakhan, Orenburg regions and Crimea. The most powerful Solar Power Plant is Vladislavovka (Crimea). Projects are also being developed for Siberia and the Far East.

Wind power. Wind energy in Russia is represented slightly worse than solar, although there are industrial installations here. The total capacity of wind generators in our country is 183.9 MW (0.08% of the entire energy system). Most of the installations are in Crimea, and the most powerful one is in Adygea—"Adyghe wind farm".

Hydropower. This is the most popular alternative energy source in Russia. About 200 river hydropower plants generate up to 20% of all energy in the country. Since 1968, there has been a tidal power plant in the Kislaya Bay in the Murmansk Region—the Kislogubskaya TPP. The largest hydroelectric power station is located on the Yenisei River—Sayano-Shushenskaya.

Geothermal energy. Due to the abundance of volcanoes, this type of energy is widespread in Kamchatka. There, 40% of the consumed energy is generated by geothermal sources. According to scientists, the potential of Kamchatka is estimated at 5000 MW, and only 80 MW of energy is generated per year. There are also geothermal stations in the Kuriles, Stavropol and Krasnodar regions.

Biofuels. Our country is one of the three pellet exporters on the European market. In Russia there are factories that create pellets and briquettes from wood residues, which are used to heat boilers and stoves.

Agricultural waste is converted into liquid fuels and biogas for diesel engines. But landfill gas is not used at all. It is simply thrown into the atmosphere, causing damage to the environment.

The above analysis shows, that despite the existing shortcomings, Renewable Energy Sources do not pose a significant threat to the health and life of the planet; unlike hydrocarbons, the environmental damage from the use of which is tangible and goes together with the activities of traditional energy companies from the moment of exploration to the moment of fuel transportation to consumers.

At the moment, the problem is that renewable energy demands much higher monetary spending due to the high cost of technologies and the process of building enterprises, despite the fact that their efficiency is much lower than that of traditional energy sources—which is the main obstacle to a complete transition to "green" energy.

Innovations in the field of creating cheap technologies in alternative electric power will allow more active use of renewable energy sources, which will lead to a decrease in the level of greenhouse gases and, as a result, to a decrease in the overall pollution on the planet. The environmental component in the activities of modern energy companies is one of the main factors that form a positive image of the company. So the world community is steadily moving to a new paradigm of socio-economic development which is based on the concept of sustainable development.

3.4 Sustainable Development Concept

The second half of the twentieth century created the foundations of sustainable development for the globe as a united system. The UN 1992 conference on environment and development brought the concept of sustainable development, which later became the "global model for the future of world civilization".

In addition to the concept of sustainable development, a number of other important international documents were adopted in the field of environmental protection, in particular, the proposals and UN conventions: Agenda 21, UN framework Convention on climate change, UN Convention on biological diversity. One of the fundamental UN documents on sustainable development was adopted in 2015 in New York by 193 UN member States in respect to the new agenda for sustainable development.

The concept of sustainable development requires balanced economic development that enables to solve not only socio-economic problems, but also environmental conservation and natural resource potential of the planet to meet human needs for future generations.

As part of the UN's 2030 agenda for sustainable development, adopted in 2015, a 15-year plan consisting of 17 sustainable development goals was developed. The UN recognized the following 17 goals as fundamental tasks in the field of sustainable development, covering all aspects of human life, including: poverty eradication, the elimination of hunger, good health and well-being, quality education, gender equality, clean water and sanitation, low-cost and clean energy, decent work and economic growth, industrialization, innovation and infrastructure, the reduction of inequalities, sustainable cities and human settlements, responsible consumption and production, the fight against climate change, conservation of marine ecosystems, conservation of terrestrial ecosystems, peace, justice and effective institutions, partnership for sustainable development.[2]

[2] Official site of the National Agency for Sustainable Development [Electronic resource]. URL: www.green-agency.ru/istoriya-formirovaniya-koncepcii-ustojchivogo-razvitiya/.

In this regard, the concepts of corporate social responsibility and social and ethical marketing of large international companies, which also make a significant contribution to the implementation of the concept of sustainable development, become particularly relevant. Corporate social responsibility, therefore, represents the aspirations of many large corporations to conduct business according to the principles of sustainable development. At the same time, each company offers and implements its own approach to increase the level of social responsibility.

Unilever became the pioneer in implementation of this policy by adopting the special program—Unilever Sustainable Living Plan (USLP). The major part of the program integrates the sustainable development into the supply chain and imposes strict standards for the greenhouse gas emissions. The social responsibility is achieved through combating discrimination advancing women's rights. The two goals intertwined in the marketing policies. Thus, 80% of the company's revenue is received in accordance with the principles of the USLP program.

PJSC MMC Norilsk Nickel can be cited as an example of a company with a socially responsible attitude towards its activities. On May 29, 2020, a diesel fuel spill occurred at the Nadezhda plant owned by this company, which was the first accident of such a large scale in the polar Arctic: more than 20 thousand tons of oil products mixed into the soil and water. An accident of a comparable scale occurred 30 years ago off the coast of Alaska (the accident of the Exxon Valdez tanker), its consequences can still be observed. It cost the culprit company more than $ 6 billion for damages and work to eliminate the consequences of the accident. Norilsk Nickel took the situation quite responsibly. It fulfilled the obligations that it took upon itself to eliminate the consequences of this accident. The work on the collection and disposal of oil products, pumping the fuel-water mixture and preparing the temporary storage warehouse continues. Complete elimination of the consequences of the accident is going to take a long time.

Thus, corporate social responsibility is the responsibility of the company, not only for its economic, but also socio-environmental impact on society and the environment. Today, social and ethical marketing is becoming an integral part of the marketing activities of many large international corporations seeking to implement the concept of sustainable development. Large international business includes in his activities programs on corporate social responsibility and promotion of sustainable development, which involve a number of social and environmental measures for all divisions of the company. In this regard, modern innovations play an important role in reducing resource and energy costs when the company carries out its commercial activities.

Moreover, since the 1990s, there has been a trend among companies to compile non-financial reports containing economic, social and environmental indicators of the company's activities in order to support global initiatives for sustainable development. So, by 2018, 93,000 non-financial corporate reports of a socio-environmental nature were issued worldwide, and a large share of them belonged to companies from the United States, Germany and the United Kingdom. By the beginning of 2020, about 100 thousand non-financial reports in the field of sustainable development were compiled worldwide.[3]

In modern conditions, public non-financial reporting becomes a guarantor of the implementation of the fundamental principles of CSR. Gradually, unified methods and standards for compiling such non-financial reports have emerged in the world. One of the main documents is the UN Global compact was adopted in 2000. Now more than 14,000 participants from 163 countries have already joined the UN initiative and 9,000 of them are business organizations. The UN global compact was created to strengthen cooperation with the private sector on sustainable development. This agreement sets out 10 principles, including labor relations and environmental protection. For example, the top managers of companies seeking to confirm their commitment to sustainable development and signatories to the UN Global compact adopt these 10 principles, thereby confirming their corporate social responsibility and implementing these socio-economic and environmental principles in their activities.[4]

Russian business starts progressively to implement the fundamental principles of social and ethical marketing in its activities. The largest Russian companies are guided by international standards in the field of sustainable development, in particular, the standard of the Global initiative for reporting and the AA1000 series of standards for the development and verification of REP.[5]

This trend is supported by the Russian Union of Industrialists and Entrepreneurs (RUIE) which in 2002 was adopted the Charter of Business and Corporate Ethics.[6] This set of standards is aimed at improving the Russian business climate and increasing the attractiveness of Russia for investors. In the same year, a non-financial reports of Russian companies national register was created. By mid-2020, 1,065 reports from 187 organizations were registered in the RSPP library of non-financial reports. Among them: 93 are environmental reports, 361 social, 375 sustainability, 238 integrated reports and 27 industry reports.[7]

[3] The official website of the Corporate Register [Electronic resource]. URL: http://www.CorporateRegister.com.

[4] Official site of the National Agency for Sustainable Development [Electronic resource]. URL: www.green-agency.ru/istoriya-formirovaniya-koncepcii-ustojchivogo-razvitiya/.

[5] Official site of the Russian Union of Industrialists and Entrepreneurs [Electronic resource]. URL: http://www.rspp.ru/simplepage/475.

[6] In the same place.

[7] Official site of the Russian Union of Industrialists and Entrepreneurs [Electronic resource]. URL: http://www.rspp.ru/simplepage/475.

4 Conclusion

The mutual influence of the level of social responsibility of business and the sustainability of its development is so strong that any even insignificant changes in the business environment are immediately reflected in the factors of social responsibility.

The decline in the level of business activity in world economic relations due to the coronavirus pandemic had a positive effect on the environment in many parts of our planet. In the social responsibility of energy companies, environmental problems are more complex and financially significant in comparison with the economic and social component. With a socially oriented business, problems in the economic and social spheres can be almost completely solved. Environmental problems however, can be resolved only in one case: the complete cessation of the activities of energy and other ecology-destroying companies, which is in principle impossible.

The development in the use of traditional energy sources, renewable energy sources, new (yet unknown to mankind) technologies should be based on a serious analysis of the environmental consequences not only at the level of a single country, but also at the level of the whole world as a whole.

In Russia, as in the rest of the world, all this processes of sustainable business development and corporate social responsibility are gradually gaining momentum. The number of interested stakeholders which are involved in these processes is gradually increasing, so it is the reliable basis for the further development of business practice in this area.

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Not for "Green": Risks of Inflating a "New-Bubble" by Applying Traditional Financial Mechanisms

Vitaly V. Demidov

1 Introduction

On the title web-page for "Green Economy" the United Nations Environment Programme defines a "green" economy as an economy that is characterized as low carbon, resource efficient and socially inclusive. While a low carbon development and resource efficiency can be understood and were many times described, for example, as "a new pattern of political and economic development aiming at reducing CO2 emissions and achieving the sustainable development of environment, economy, and society" (Yuan et al. 2011, p. 1711), to be socially inclusive is usually understood by everyone in its own manner, which tries to explore social behaviour and socio-centric development. Social equality, social justice, social inclusiveness and other socio-oriented categories of the social pattern of a "green" development make it vague in many cases, rather than specific. For instance, social inclusiveness can include efforts to secure most vulnerable people, to increase their quality of life, to increase their income and secure them financially. However, these efforts depend on economic and financial stability of the whole economy, and "green" economy should not be an exception. Hence, there are certain assumptions that "green" transition has to be resilient to financial shocks as well as not to cause them itself. As such, "green" finance, applied for "green" economy, has to be resilient as well.

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2 Methodology

This article investigates weak sides of "green" products by using critical thinking and critical evaluation when these products are compared with their traditional analogues. The argumentation is made based on causality that "green" financial products have the same roots as the traditional ones do, to suggest that if left unspecific for demands of "green" economy (in terms of what "green" means), "green" funding is likely to suffer from traditional financial vulnerabilities. The conclusion is made by discussion, however further research on this topic requires not only qualitative analysis already produced in this article, but empiric evidence and quantitative analysis of prolonged financial performance of examined "green" financial instruments.

2.1 Funding "Green" Economy

The "green" economy would never happen on its own, though historically humankind grew from nature-oriented development, the industrial revolution changed the orientation toward more wealth and technology superiority disregarding environmentally friendly and socio centric existence. Nowadays, the word "green" is becoming more and more popular, perhaps, causing the term "green" to become bias, ambiguous, hard to address explicitly. However, governments, NGOs, international organizations, business, academia, media, people—almost everyone speaks freely in favour of a more sustainable development. This year the break-through Paris Agreement 2015 celebrates its first small anniversary—5 years, though having already faced some true "commitments" of the USA's to exit the Agreement as it would be an "unfair economic burden imposed on American workers, businesses and taxpayers" (Mike Pompeo) "making the United States the only country in the world that will not participate in the pact, as global temperatures are set to rise 3C and worsening extreme weather will drive millions into poverty".[1] Obviously, the ambitious goals of Paris Agreement 2015 are actually hard to achieve since the most powerful country and economy in the world simply gives up saying they have already done a lot in terms of reducing emissions and carbon footprints. Five years later the date of the signature and the Agreement is still on the same bottom-line and still "aims to strengthen the ability of countries to deal with the impacts of climate change"[2] calling for technology framework transformation, regulatory framework transformation and financial flows to start flowing. While technology and regulatory frameworks are more or less clear how to be maintained (through inventions and different legislation), financial flows may struggle to find the right source of funding.

[1] https://www.theguardian.com/us-news/2019/nov/04/donald-trump-climate-crisis-exit-paris-agreement.

[2] https://cop23.unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

The money quest seems to be the major challenge of realizing a “green” dream of a sustainable development. For instance, to execute a “low-carbon” scenario needs 93 tln USD to be invested into infrastructure over the period up to 2032 (OECD 2017). As the research estimates, the current financial sharing of the sources of required investments is uniform with debt funding the majority of money invested into infrastructure projects. This tendency is strong enough to continue while “green” bonds are expected to be the main source of funding. The period of 2008—2018 resulted in the “green” bond issuance by different institutions, both governmental and non-governmental, worth 521 bln USD while first six months of 2019 alone added significant 100 bln USD to the issuance with estimates for the whole year of 2019 to add 250 bln USD—a half of what was issued from 2008 to 2018 (Beschloss and Mashayekhi 2019).

Apparently, “green” finance to fund “green” economy and “green” growth is becoming something that all corporate financiers and investment bankers like—something solid with “big” money. Therefore, financial corporations are ready and eager to offer various types of instruments applicable to going “green”. Noh (2018) specifies the following types of “green” financial products:

- “Green” mortgages;
- “Green” home equity loans;
- “Green” commercial building loans;
- “Green” car loans;
- “Green” cards;
- “Green” project finance;
- “Green” securitization;
- “Green” venture capital and private equity;
- “Green” indices;
- “Green” fiscal funds;
- “Green” investment funds;
- Carbon funds;
- “Green” insurance;
- Weather derivatives.

At the same time, applying traditional financial instruments might not be right move, since such instruments have already proved to provoke financial turbulence. This makes not all financial products suitable for sustaining “green” economy by funding “green” projects, still exposing risks of inflating financial “bubbles” due to speculative sentiments.

2.2 New "Green" Look for Old Vulnerabilities: Securitization, Sale-and-Repurchase, Derivatives

As it has already been discussed previously, the transfer toward the "green" economy needs substantial funding to allow innovation, technology and progress going on. However, if we look further on the potential of issuing "green" bonds, which are considered to significantly contribute to the "green" shift, we might discover certain risks coming from the bond market and financial tools applied in practice when trading stocks. With factors and categories held equal, the following vulnerabilities can be outlined.

Firstly, the risk related to securitization if this mechanism is used in its traditional economic insight. Arguably or not, appetite for securitization popped up the disastrous financial crisis of the American mortgage and loan markets in 2007. With prices and assets falling and arrears and nonpayment rising securitized loans got domino effect forcing firms and banks to call for a bankruptcy, if there was no one to save them. As such, it should be fairly expected that securitization as a financial tool to accumulate funds, if not banned by the designated financial regulator, would be widely avoided by firms which no longer agree to bear risks of toxic assets. Instead, securitization holds confident position and remains to serve an essential mean for economic actors to begin with when they are short of funds or simply want to raise extra (Schwarcz 2013).

In this regard, since recently "green" securitization has gained much attention offering excessive financial resources enough to fund "green" projects, it is worth exploring if there is any difference between used to be asset backed securitization and new "green" securitization. Particularly, it is worth being addressed with the new European Union Securitization Regulation (Regulation (EU) 2017/2402) entered into force in January 2019 suggesting Simple, Transparent, and Standardized (STS) assessment of falling within the framework.

The "green" securitization has proved to become a quite competitive tool to attract investment. According to Climate Bond Initiative research (Climate Bond Initiative 2017) annual issuance of "green" asset backed securities showed steady dynamics growing from some insignificant 0,1 bln USD in 2013 to rather impressive 4,7 bln USD in 2016. As this Initiative forecasts, annual issuance of "green" asset backed securities has a decent chance to line up with the value of 280–380 bln USD by 2035 (ibid.). Thus, with measurable annual added value of "green" asset backed securities far away exceeding total 1–1,5 tln USD by 2035 (a raw estimate based on the Climate Bond Initiative's forecast), it is quite reasonable to expect that "green" securitization would not trigger any new financial crunch when a "new-bubble" burst.

International Capital Market Association defines a "green" securitized bond as "a bond collateralized by one or more specific Green Project(s), including but not limited to covered bonds, ABS, MBS, and other structures; and aligned with the GBP. The first source of repayment is generally the cash flows of the asset" (International Capital Market Association 2018, p. 7). Some examples of "green" assets applicable for "green" bonding could be (Climate Bond Initiative 2017):

- Mortgages to "green" building;
- Car loans to electric vehicles and hybrids;
- Loans to green small-to-medium enterprises;
- Leases from solar and wind assets;
- Loans for energy efficiency upgrades;
- Loans to battery and storage projects.

Nevertheless, since a "green" securitized bond is still a bond issued on the basis of a certain asset with the same principle of repayment by cash flows of the asset, it might be securitized but not secured against the same financial failures—arrears and nonpayment—which have already lead to numerous economic distresses. The weakest part in the securitization mechanism is an intention to get one's funds using someone else's funds hushing the real output that could secure funds, but supposing the cash flows would not change or stop.

The latest statistics show that new car sales in the United States are still thinly represented by hybrid-electric, plug-in hybrid-electric and electric vehicles. In 2019 the share of sales of hybrids was 2% of the total light car market while plug-in hybrids and all-electrics together reached 2.1% of this market (U.S. Department of Energy 2020). Apparently, these statistics suggest that buying an electric car remains a matter of a sustainable consumption which is wise, moral and voluntary. However, if these figures are assumed to be much higher with the share over 50–60%, and firms massively issue "green" securitized bonds backed by the type of assets as 'car loans to electric vehicles and hybrids', what guaranties would be in place to avoid inflating a "new-bubble" since the same Unites States face the national outstanding car loan balances worth 1,17tln USD as of the first three months of 2020 (Statista 2020).

For instance, Kanamura (2020) states that "green" bonds should not be addressed "green" from the very inception. By examining empirical evidence of correlations between commodities prices and major green indices the author concludes that the Solactive green bond index has fewer environmental features when it comes to measuring "green" value, unlike two other major indices—the Bloomberg Barclays MSCI and the S&P green bond indices—which correlated positively with WTI and Brent crude oil prices. Instead, policies applied after the Paris Agreement was signed in 2016 suggest that "green" bond issuance, as a 'get-funds tool', is becoming more and more popular to finance projects, especially those covering renewable energy, simultaneously supporting climate commitments and reducing emissions worldwide (Tolliver et al. 2020). In a rapidly changing world with the "green" bonds market and the clean energy market enhancing, investors should decide on "green" bonds and clean energy investments responsibly entailing risks to support "green" investments rather that produce negative effects of pricing, withdrawals or any other bad externality (Liu et al. 2021).

'Responsible issuance' might turn a key feature in the "green" bond dilemma. According to the Climate Bond Initiative data, overall climate-aligned bonds estimated 1,45tln USD in 2018 with the share of 389 bln USD, or 26.8%, of simply labeled "green" bonds.[3] Once there is still little confidence that "green" bonds are the source of funding "green" economic transformation but not the source of a new "green" income of hot speculative money, an option to securitize them makes things worse. There are strong signs, that "green" securitization tends to switch old financial imbalances into "green" light.

In much the same way, sale-and-repurchase transactions (repo) with "green" bonds—the second financial vulnerability of three covered by the present article—tends to justify financial corporations' strong desire to produce extra profit using potential that combined loan and bond markets bring, hiding behind the "green" edge. Even if the discourse over "green" bonds as a right sustainable mean to finance the "green" transformation and, as a consequence, worth to invest in (Flammer 2018), or as a wrong unsustainable mean that could undermine social stability by strengthening racial inequalities (Bigger and Millington 2019), is skipped, let's focus on typical financial instruments in use, such as repo transactions, and what risks they have.

In the financial practice, the repo market can be divided into two main categories. The first is represented by tri-party agreements when a bank plays a "referee" between a borrower and a lender, while the second, or a market of bilateral repurchases, is a "playground" of hedge funds, financial corporations and unregulated institutions of this kind, much exceeding the volume of repo transactions of the first market (Gorton et al. 2020). Moreover, the tri-party repo market would not appear to be of a great interest coming from multi-billion hedge funds if it did not offer an access to liquidity and lavish financial resources.

Though, some researchers (Fuhrer 2018; Corradin and Maddaloni 2020) made attempts to quantitively investigate the role of repo transactions and the market to find the evidence that the repo reacts on economic shocks and financial instabilities accordingly, depending on quotes, traders and central banks' policies to smooth fallouts. The role that sale-and-repurchase mechanism plays is significant when it refers to obtaining necessary funds or quickly fuel liquidity, contributing to valuation of assets and guarantying consistent financial position (Garleanu and Pedersen 2011; Boissel et al. 2017). At the same time, this very liquidity may cause a rally for it to avoid insolvency as it once happened during the great panic of 2007—2009 global financial crunch (Gorton and Metrick 2012). According to the research, "the run on repo"

[3] https://www.intuition.com/green-bonds-are-growing-fast-but-there-are-challenges/.

was provoked by the behaviour of lenders who refused to provide short-term funding with historical spreads in use. Soon after repo haircuts rocketed to reach historical levels, while banks had to deal with wide-scale exodus of funds from accounts.

In this context, Angus McCrone, chief editor at BloombergNEF, points out that with a sustainable debt market having reached 1 tln USD as of October 2019 as well as with “green” bonds’ sharing 77% of the market, or some 788 bln USD, the world leading investment corporations and banks are to get sight of this “green” money pie (BloombergNEF 2019). As such, firms-borrowers issue “green” bonds to sincerely fund various “green” projects, e.g. renewable solar energy battery production or cleaner water equipment production or waste management production, and grant these bonds to get a bank loan to increase their own available cash assets. In their turn, firms-lenders possessing these “green” bonds, which are rated as high quality assets, can easily resell them to get money to buy new high quality “green” bonds for a new reselling with fingers crossed that the time gap between the near and reverse legs will close in a timely manner and the pyramid would not collapse. Thanks to the sell-and-repurchase mechanism the recent amount of 788 bln USD of “green” bonds risk producing a feasible market of repo worth 1.6tln USD, if simply doubled,—four times higher the level of repos in the data analysis by Krishnamurthy et al. (2014). However, “green” bonds are backed at least by the aim to complete a project in the real world, unlike the repo market where money makes solely money, especially if borrowed overnight to quickly raise liquidity.

Although, Krishnamurthy et al. (2014) conclude that with a closer look to the structure of pre-crisis repos where 90% originated from the bonds issued by U.S. Treasury or other government agencies, 10% of lower rated securities were unlikely to lead to the financial catastrophe, it is the same matter of trust whether government bonds would not default to trigger a repo crisis or a matter of taste whether 1,6tln USD is high enough to name a “bubble’. Nevertheless, the question is raised to understand if potential vulnerabilities are fine to live with. Hence, not all financial instruments are to be suitable for funding “green” economy without risks of causing financial disturbances. Neither is to be the market of derivatives—the third financial option explored by the author to unveil its vulnerabilities. Besides Michael Lewis’ “The Big Short: Inside the Doomsday Machine” trying to expose the truth about derivatives and the role they played in 2007, there are some other doubts whether they could become a sustainable part of the “green” economy.

Fundamentally the market of derivatives is purely a financial invention since it is represented not by a product or a tangible asset, but the price or the value derived from products or tangible assets or from the price, or in some cases—estimates, of instruments or events that derivatives are to settle (e.g. weather derivatives which are further discussed in this article). Financially the market of derivatives unleashes a plenty of opportunities for many economic entities from simple speculations with futures, options, forwards etc. to hedging against undesirable payoffs. Derivatives attracting financial resources stimulate economic growth (Haiss and Sammer 2010; Rodrigues et al. 2012), securing stability both in real sector and on financial markets as firms use derivatives to hedge potential risks and reduce potential losses (Tanha and Dempsey 2016). Largely due to this positive economic effect emerging countries decide to have a more developed national derivative market designing respective financial policies to enhance financial activities and transactions with derivatives (Atilgan et al. 2016). Levine et al. (2000) stress out that with all pros of derivative markets governments should chose in favour of financial development by applying new regulatory frameworks, reforming systems and completing supportive measures. As a consequence, the market attracts new participants, even among households whose participation is influence by the quality of services, own wealth and financial literacy (Hsiao and Tsai 2018), while types of derivatives continue to grow offering more complex and perhaps more profitable ones.

Evidently, the complexity of the market of derivatives hides the main risks of inflating the "bubble", as risk management and the option to hedge practised by companies is only the brighter side of the coin, though still suffering, for example, from such vulnerabilities as risks of uncontrolled and unsecured 'credit default swaps' which are also blamed for initiating the crisis in the USA in 2007. Since a derivative is not limited in terms of an asset, a price, an event etc. to derive from, professionals can offer various types of futures including bets, different rates, e.g. unemployment, cargo logistics, cinema as well as weather (snow or rain, temperature, hurricane etc.)—a particularly interesting derivative. This might be much of a moral discussion arguing that financial interests and financial commercialization should not become exclusive goals of economic performance, but fade before the hazards of unsustainable development. Neither should weather and environment become a derived asset to trade with or for.

Anyway, just as any other derivative, weather derivatives are financial tools used to mitigate potential risks and losses coming from unexpected weather conditions or changes, e.g. heavy rain or snow, wind blow, high or low temperatures, mind or severe seasons (mind winter or cold summer) etc. To calculate the value of a derivative an operating company, or a hedge fund, uses the corresponding weather index, available almost in every country (weather and agriculture forecasts). A firm which revenue might suffer from weather changes can secure future flows by buying futures of this kind, however, acts of gods, or unexpected catastrophes, are to be covered with insurance policies or government bailouts. Additionally, weather derivatives help to keep running costs predictable avoiding to go much into the red zone.

Jewson et al. (2005) argue that there are several main reasons why a company decide to hedge against potential weather losses, including an intention to secure a stock value of the company, an ability to get cheaper money in terms of interests paid, an advantage to cover losses at the expense of a hedge fund thus limit actual costs and charges. Alexandridis and Zapranis (2013) generalize industries by types and underline what risks these industries can face regarding weather conditions (Table 1).

Nevertheless, weather derivatives as a financial tool to keep risks under control may be justified since it helps firms to operate at a minimum risk level and secure money flows—avoid potential big losses in the future. At the same time, once "green" economy aims at reducing hazardous footprints of the current unsustainable development as well as at reducing anthropologically

Table 1 Industries with weather exposure and the type of risk they face borrowed from Alexandridis and Zapranis (2013)

Hedger	*Weather type*	*Risks*
Agricultural industry	Temperature/precipitation	Significant crop losses due to extreme temperatures or rainfall
Air companies	Wind	Cancellation of flights during windy days
Airports	Frost days	Higher operational costs
Amusement parks	Temperature/precipitation	Fewer visitors during cold or rainy days
Beverage producers	Temperature	Lower sales during cool su mmers
Building material companies	Temperature/snowfall	Lower sales during severe winters (construction sites sh ut down)
Construction companies	Temperature/snowfall/rainfall	Delays in meeting schedules during periods of poor weather
Energy consumers	Temperature	Higher heating/cooling costs during cold winters and hot su mmers
Energy industry	Temperature	Lower sales during warm winters or cool summers
Hotels	Temperature/precipitation	Fewer visitors during rainy or cold periods
Hydroelectric power generation	Precipitation	Lower revenue during periods of drought
Municipal governments	Snowfall	Higher snow removal costs during winters with above-average snowfall
Road salt companies	Snowfall	Lower revenues d uring low snowfall winters
Ski resorts	Snowfall	Lower revenue during winters with below-average snowfall
Transportation	Wind/Snowfall	Cancellation of ship services d ue to wind or buses due to blocked road

driven climate change that cause unpredictable and devastating weather conditions, e.g. fires, draughts, floods, winds etc., something that allows a company financially “guard” itself against any kind of weather and natural phenomenon would rather be an oxymoron. If the ends of sustainable development through “green” concepts is to normalize the environment, eventually in the long run there would not be those unexpectable weather changes and conditions imposing risks characterized in Table 1. Hence, weather derivatives can be used in the traditional economic model, but is not logically acceptable to be given a status of a “green” instrument. As far as the purpose of hedging fades, the purpose that only remains is to speculate with existing types of derivatives. As such, it is the same old hot money which is still strong enough to inflate “bubbles” in order to maximize profits and flowing from one financial market to another.

3 Results

The discussion suggests that “green” financial instruments, in the mere that they are presently applied, are the same traditional corporate finance products which have already lead to numerous financial instabilities. “Green” securitization is likely to cause a financial crunch if eagerness to get interest profit is higher than an intention to build “green” infrastructure. Massive emission of “green” bonds is likely to attract “hot” money of those who have nothing in common with “green” transition, but with free available capitals and an opportunity to speculate with something new, especially when traditional financial markets are short of low-risk instruments. A repo market of “green” bonds is not secured against risks of collapsing if a panic happen and there is a run on repo. “Green” derivatives are some kind of an oxymoron in terms of “green” as they are based on weather indices, weather forecasts, natural phenomena etc., which are not assets on the one hand, while nature should not be trade with or for, on the other.

“Green” financial tools are more likely to become “paint them green” financial products still exposing vulnerabilities. In the truly “green” point of view, the painted “green” label is perceived to be more of a bogus measure rather than an effective policy. In order to investigate these vulnerabilities, an empirical research is needed to explore financial characteristics of such vulnerabilities, e.g. debt rising, interests rates increasing, withdrawals, flow shortages, bankruptcies etc.

4 Conclusion

The reviewed “green” financial instrument after a closer look are still much of the products of traditional economy with an attempt to apply “green” narratives to make them “green” and, thus, applicable to fund the transition towards “green” economy. The “green” economy concept is developed to mitigate on-going destructive economic development which is based on traditional energy, natural resources depletion, degradation, deforestation as well as on the idea of wealth superiority and profit maximization. If "green" economy in the context of industry 4.0 is to achieve "green" growth and, what is more, sustainable development free of crisis and traditional economic and financial vulnerabilities, the "green" growth in this context should be free of financial products which may cause financial imbalances and lead to inflating financial "bubbles". However, if some of the financial instruments, e.g. "green" bonds, are in use to raise necessary funds to finance "green" projects, the issuance should be strictly regulated under obligatory rules of issuance to limit uncontrollable issuance and prevent bursting of a "new-bubble" of "green" associated securities.

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Green Bonds in the System of International Environmental Financing of Industry 4.0 Projects

Raisa B. Nozdreva

1 Introduction

In recent decades, there has been an activation of the environmental strategy for the development of the global economy towards the implementation of the Industry 4.0 concept, which includes the massive introduction of cyber-physical systems into production and management, fully automated and robotic processes, artificial intelligence, big data, virtual and augmented reality, the Internet of things, revolutionary achievements bio- and neurotechnology. Despite some positive results in environmental protection that were achieved at the end of the twentieth century, nowadays there is an aggravation of environmental problems, which required changes both in the world economy and in the international financial system. In particular, the dynamic development of the economies of a number of developing countries, primarily China, contributes to environmental pollution. First of all, such environmental risks as the growth of greenhouse gas emissions, climate change, lack of fresh water and others are noted, which are among the first five threats to world stability. In addition, the increase in the number of man-made disasters aggravates the difficult situation in the environment and requires urgent measures from companies and governments of states to actively implement environmental projects both at the national and regional and international levels, and this, in turn, causes a significant increase in financial costs and investments. For

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example, the EU's Energy Transition Program alone is expected to spend 379 billion euros annually from 2020.

Analyzing the issues off financing environmental protection and green management projects in retrospect, it should be noted the improvement of the incentive system for environmental investments in the context of socially responsible business. Previously, the main method was the reduction of tax collections or their complete exemption, but now this is clearly not enough and the development of a variety of, including innovative, means of stimulating investors in environmental protection projects can be observed.

2 Materials and Methods

In the course of the study the works of Russian and foreign scientists, experts in the field of industry 4.0, international financial system and ecological environment were used. The seminal works on Industry 4.0 are by Klaus Schwab, who points out the importance of adhering to the principle of environmental protection in the context of the massive introduction of cyber-physical systems into production: "New ways of using technology to change behaviour and our systems of production and consumption also offer the potential for supporting the regeneration and preservation of natural environments, rather than creating hidden costs in the form of externalities" (Schwab 2016). Also important are the works of Alasdair Gilchrist, Ibrahim Garbie, which emphasize that the modern development of Industry 4.0 is carried out using cyber-physical systems and environmentally friendly technologies.

At the same time, environmental projects are very costly, which makes it necessary to develop and improve new methods of financial incentives for investors, one of which is the so-called green bonds.

Harvard Business School professors of Business Administration George Serafeim and Malcolm Baker and Daniel Bergstresser of Brandeis University and Jeffrey Wurgler of NYU's Stern School of Business have long been interested in investor motivations that go beyond pure financial return to include environmental, social, and governance (ESG) criteria. The test they used was "to look at how the money from the bond flows into actual projects, and whether those projects are going to deliver environmental benefits". In a paper for the National Bureau of Economic Research, Financing the Response to Climate Change The Pricing and Ownership of U.S. Green Bondsthey have written, that while green bonds have been issued by banks and corporations as well, the researchers focused on municipal bonds, which are the most ubiquitous green bonds historically in the United States, and the easiest to track thanks to the availability of government data. (Baker et al. 2018).At work, the deputy. Boris Porfiryev, Director of the Institute for National Economy Forecasting, Russian Academy of Sciences, "Green" trends in the global financial system ", assesses" green "finance as a new factor in global economic dynamics". The importance and linkage of green finance with the UN Sustainable Development Goals is emphasized (Porfiriev 2016). Head of Primakov

IMEMO Department, Lyudmila Khudyakova in the article "International cooperation in the development of green finance" defines the role of international cooperation in attracting private capital to green finance, analyzes incentives and obstacles for private financial intermediaries and investors to participate in it, identifies the features of the main green financial tools; considers climatic and other environmental risks facing the financial sector (Khudyakova 2017).

In the course of the study, the author applied the methods of comparison, generalization, as well as microeconomic analysis tools with extrapolation to the planning trend of green bond sphere.

In addition to in this work along with the official documentation, interviews with foreign experts in the field of ecological problems and financial tools of Japanese universities (Keio daigaku, Kokusai kirisutokyodaigaku) are used as an empirical base.

3 Results

3.1 International Agreements For the Protection of the Environment and the Industry 4.0 Concept

The basic international documents in ensuring environmental protection were the Declaration of the UN Conference on Environment and Development in 1992, which defined the obligations of states in the context of the concept of sustainable development, as well as the Kyoto Protocol of 1997, supplementing the relevant UN Convention on Climate Change. The latter came into force in February 2005 and was signed by 159 countries. This agreement, first of all, set the task to achieve a reduction or stabilization of the amount of greenhouse gas emissions on a global scale in order to prevent an increase in the temperature on the earth by more than 2 degrees.

An important achievement of the Kyoto Agreement was the introduction of a mechanism for the market regulation of greenhouse gas emissions through the introduction of cross-border trading in quotas not only at the cross-border level between countries, but also at the local level between economic entities. As a result, by 2012, compared to 1990, the countries managed to achieve a 5.2% reduction in the total average level of emissions of 6 types of gases that cause global warming, namely: carbon dioxide, methane, hydrofluorocarbons, fluorocarbons, nitrous oxide, sulfur hexafluoride.

In general, it should be emphasized that these documents played a special role in the formation of eco-consciousness of government structures, business community and the entire population of the planet.

In 2013, the Kyoto-2 Agreement was adopted, however, due to the need to implement large expenses, especially in connection with the introduction of strict restrictive measures for CO2 emissions - the so-called "hot air", as well as the vagueness of control measures and responsibility for the implementation of the indicated decisions and the lack of an appropriate system of sanctions for non-implementation by many countries, it was not ratified, and subsequently a number of them refused to participate in the implementation of its provisions (for example, Japan).

Since 2015, voices have begun to sound quite weighty regarding the rejection of the Kyoto Agreements and their replacement by a more perfect international document with a well-developed, effective system of control and strict responsibility for the implementation of adopted resolutions. On it was assumed that the restrictive provisions would be binding and strict reporting and monitoring of implementation. In particular, Russia made such a proposal.

In 2016, such a new global climate agreement was the Paris Agreement, which replaced Kyoto Protocols 1 and 2 and already included 194 countries. However, it also did not create a developed clear system of mandatory implementation of decisions made and its viability was called into question.

In this case, not all countries, including Russia, have ratified the Paris Climate Agreement, and the United States in June 2017 announced its withdrawal from it altogether. Currently, there is an acute issue of including in such agreements a system of effective control measures over the fulfillment by countries of their obligations.

International theories, along with the triune concept of sustainable development, which raises questions of environmental protection, should now include the Concept of the Fourth Industrial Revolution—Industry 4.0, since it defines the task of improving the ecological environment and human ecosystem, including his life, work and leisure at the expense of mass introduction of cyber-physical technologies and equipment.

In 2011 in Germany, when formulating an industrial development strategy, and then in 2016 at the World Economic Forum in Davos, the concept of Industry 4.0 was introduced, which implies the introduction of artificial intelligence, robotization, virtual and augmented reality, the Internet of Things into the world economy and people's lives. revolutionary advances in bio— and neurotechnology, which presuppose the preservation of nature and the improvement of the human ecosystem as the basis.

3.2 *Financial System for Investing in Environmental Protection Projects*

Implementation of environmental protection projects is associated with significant financial costs and, as a rule, does not entail significant profits in the short term, as a result of which there is a reduced interest in their relation on the part of relevant investors. In addition, in most cases, companies are unable to implement green projects independently, in connection with which recently new means of joint investment have been sought with the connection of a variety of credit and financial incentive instruments, which include green bonds.

Table 1 Credit and financial instruments for investing in environmental protection projects

Green loans (GK)
Green Private Equity Funds (GPE)
Venture Capital Funds (GVC)
Green ETF Exchange Traded Funds (GETF)
Greenmutualfunds (GPIF)
Green banks (GB)
Green Insurance (GI)
Green Public–Private Partnership (GGPP)
Green Bonds (Bonds) (GBonds)

And interest in responsible investing has grown. In 2015 71% of global investor were interested in sustainable investing and in 2019—85.5% expressed an interest for this strategic (Table 1).

3.3 Green Bonds (GBonds) as an Innovative and Promising Means of Financing Environmental Projects

One of the relatively new and actively developing forms of international financing for environmental protection projects are green bonds. Green bonds are debt instruments issued to fund projects that have a positive environmental or climate impact. Proceeds from these bonds are typically earmarked for green projects and are backed by the issuer's entire balance sheet. This instrument is actively used to develop low-carbon technologies, including renewable energy sources, as well as to invest in international projects to reduce climate risks in the economy.

Most often, they are issued by international and regional financial institutions, primarily international banks, but at present interest in them has increased in the world and state financial institutions and major companies have become involved in their issue. Green bonds are a financial instrument alternative to bank lending. It actively expands the system of investing financial resources for the protection of the natural environment and makes them more attractive to investors.

For the first time, green bonds began to be used in world finance only from the mid-2000s—early 2010s. In 2007, LuxSE, a pioneer in green finance, listed the first (ever) green bond to enter the market: the European Investment Bank's "Climate Awareness Bond".

Since then, this exchange has become the leading venue for this asset class. Today, more than 160 green bonds list on LuxSE markets (Luxembourg Stock Exchange, 2020). Issuers range from sovereigns, Public International Bodies, agencies and development banks to financial institutions and corporates. However, in 2019, new issues of green bonds topped $258 billion worldwide—jumping 51% in one year. Overall, green bonds can be diversified across a number of different sectors (Maltais and Nykvist 2020).

As for the country example, green bonds appeared on the Japanese market only in 2014. The Japanese Development Bank became their issuer, and the volume amounted to 750 million euros. At the same time, he provided these securities with a state guarantee and insurance, using credit funds from American banks Bank of America, Merrill Lynch, Morgan Stanley, Citi vank and the Japanese bank Daiwa. In 2015, green bonds in the amount of $ 500 million, issued by the Japanese private bank Sumitomo Mitsui Banking Corporation (SMBC). In Russia, the first green bonds were issued—in December 2018.

It should be noted, however, that the world is currently experiencing a rapid growth in demand for green bonds, which is outstripping their supply. So, in 2019, the volume of issued green bonds amounted to over $ 120 billion, while in 2013 it was determined at $ 1 billion (Environmental-Finance 2020). As for the potential of this type of debt, then it is at the level of 160 trillion dollars and tends to grow. For example, it is expected to spend 1 trillion dollars annually on infrastructure projects alone (Porfiriev 2016) (Table 2).

Compiled from materials: Financial Markets KfW USD Green Bond 10 year USD 2bn 1.75% due September 2020 www.kfw.de/investor-relations.

Currently, green bonds can be viewed as a promising instrument for debt financing of low-carbon technologies, projects for the development of renewable energy sources, leveling climate risks in the economy, reducing greenhouse gas emissions and improving the ecosystems of human life. Proof of this is the fact that investors in China and India are very active in acquiring green bonds.

Table 2 World operations of green bonds

by Geografi, % (2019)		*by Investment type, % (2019)*		*By Sector, (2015–2019)$ B (Bloomberg Barclays MSCI Global Green Bond Index)*	
Asia	336	Central Bank, OfficialInstitution	551	Alternative Energy	143.8 (30.4)
Americas	224	Banks	333	Green Building	63,5 (10.7)
UK	115	Asset Manager	112	Sustainable Transport	58,7 (3.7)
Germany	110	Insurance company, Pensions Funds	22	Energy Efficiency	47,6 (9.5)
France	6 6	other	22	Sustainable Water	23.8 (3.1)
Scandinavia	55			Pollution Prevention	18.1 (1.4)
other	44			Climate Adaptation	15 (1.6)
				SustainableForestry/ Agriculture	11.3 (1.1)

At the same time, in China this is primarily explained by the fact that there is a rejection of the model of economic development with the assumption of a significant level of environmental pollution and intensive energy consumption and a transition to a model of a green economy and sustainable development. In addition, such a transition is facilitated by a significant contribution to this process from the Chinese private sector, which assumes 85–90% of the costs of purchasing green bonds, while the state only 10–15%.

At present, the standardization and certification of this financial instrument, as well as the control measures over its use, require serious study due to its insufficiency, which does not completely exclude the possibility of diverting the money of these funds for other purposes. This circumstance determines a very cautious attitude of Japanese investors to green bonds.

Germany is also being cautious. It issue first multi-billion dollar government green bonds in just 2019. One catalyst behind this was the European Central Bank's announcement that the environment would become a "mission critical" priority going forward.

During times of both extreme exuberance and market crisis, companies with higher sustainability ratings have outperformed their respective benchmark. However, there is still a long way to go. Even with the record issuance of green bonds in 2019, they make up just 3% of all global bonds issued (Neufeld 2020).

It should be clarified that in Russia there is some lag in the definition of a full-fledged national system of carbon regulation, green projects and green investment. In Russia, the first green bonds appeared on the Moscow Exchange in December 2018, and only in August 2020 the Ministry of Economic Development of the Russian Federation developed the first version of the concept of the Russian system of climate projects, which defines approaches to the implementation of projects to reduce emissions of greenhouse gases and increase the absorptive capacity of ecosystems by Russian companies.

The cautious approach to green bonds is also explained by the fact that they are divided into marked and unmarked. To confirm that the paper has the status of exactly green bonds, it (and the project) is analyzed by special auditing companies and rating agencies and certified, that is, they are marked, thereby determining its intended green. Thus, marked green bonds can be exchanged for monetary resources only for environmental projects. However, there are many unmarked green bonds issued that do not go through the certification procedure and the scope of which is very blurred. Unmarked green bonds can be misused and subject to financial fraud. In general, a system of strict control over the spending of allocated funds has not yet been developed for green bonds, and mechanisms for tracking their route have not been created.

Currently, green investment involves not only corporate and institutional investors, but also retail, individual investors who invest in green bonds of international and regional financial organizations with high ratings. For example, the investment objects are green bonds of the International Finance Corporation (part of the World Bank Group), the European Investment Bank, the International Bank for Reconstruction and Development, etc.)

In the past ten years, the green bond market has gone from nonexistent to $188 billion in 2019. Investors are placing a premium on green bonds and are willing to accept a lower rate of return in exchange for the environmental benefits. Given the typical duration of municipal bonds, this yield difference amounts to a green bond price that is in the range of 0.6–2% higher than a comparable brown bond (Fig. 1).

In 2018—177 billion dollars, in 2019—188 billion dollars (Pronina and Freke 2019).

In addition, the researchers found that green bonds were more concentrated in their ownership in a small group of investors—reflecting the smaller subset of investors who place value on environmental benefits, such as funds that have some green or social investing orientation.

As green bonds continue to gain in popularity, the researchers are interested to see if they continue to command a premium price. As more green bonds are issued, especially by government entities in Europe and China, their price could fall due to an increase in supply. On the other hand, from 2013 as they continue to gain in popularity, more investors could value green bonds, pushing up price due to increased demand (Clapp and Pillay 2017).

Increasingly, investors are seeing both the financial and social imperative for sustainable investing. In particular, the rapid growth of green bonds—a fixed income investment that is designed to raise funds for the climate or environment—is booming.

Fig. 1 Green bond issue volume, USD billion (*Source* Bloomberg)

By the end of 2020, $45 trillion in assets will adhere to sustainable practices, including ESG (environmental, social, and governance) principles.

Despite the loss of confidence from COVID-19, investors flocked to sustainable-focused funds. In fact, global fund flows hit record levels for Q2 of 2020—surpassing $71 billion (Neufeld 2020).For example, Thailand will offer up to 30 billion baht of 15-year green bonds to investors on September 2020 to help finance coronavirus support measures (the bonds will be offered to institutional investors) (Bangkok Post and Reuters, 24 Jul 2020).

As a result of the issuance of green bonds, which are a very effective innovative financial instrument, green assets are created and significantly replenished both for new projects and for refinancing old ones, the goals of which are not only environmental protection and measures to adapt to climate change, but which important in modern conditions, the fight against COVID-19.

4 Conclusions

At the turn of the XX–XXI centuries, there is a significant increase in the development of a green and socio-ethical orientation of state policy and business development, in which an important role was played by the activation of the activities of the general public, demanding a green development of the economy and improving human living conditions in the context of the implementation of the concept of Industry 4.0, which develops these approaches in the context of the massive introduction of cyber-physical systems into production and prioritizes ensuring the viability of global ecosystems. Tightening legal norms regarding environmental protection by the state and international organizations are forcing companies to include measures to preserve clean air, water and soil in their financial and management plans, to carry out innovative developments taking into account environmental requirements, to strive for “zero” production waste, to build development strategies in the context of climate change and COVID-19 challenges.

Also important are the tasks of preventing the planet’s climate from warming, preserving its resources for future generations, the growth of energy-efficient production with a high degree of robotization and automation of production processes, the development of renewable energy sources, low-carbon Driverless Cars, green and smart construction, etc.

At the same time, special attention is paid to ensuring the scientific and technical base for environmental protection, regulation and improvement of the public–private system for financing projects using environmentally friendly technologies and cyber-physical systems that have reached the stage of commercialization and ensure growth in the context of the active development of Industry 4.0.

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Greener Transport for North America

Egor V. Pak and Egor I. Abramov

1 Introduction

Green logistics is one of the key pillars of the sustainable development concept. 'Green' in the context of sustainability in logistics means turning all related operations into environmentally friendly ones, for instance, green transport, green warehousing, green procurement, green packaging, etc. As long as transportation accounts for roughly 60% in the overall logistics costs, green transport should be studied precisely. In sustainability terms green transport could be viewed as 'a notion that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs' (Black 1996).

Marking the 5th anniversary of the Sustainable Development Goals (SDGs) transportation as a connecting operation has generally sustained the trend on eco-friendliness of the world economy. Several SDGs encompass the transport and logistics agenda (i.e. Goals 7, 9, 11, 12, 13, 14, 15). At the same time, transport is still one of the main polluters of the environment. Transportation accounts for 24% of direct CO2 emissions and when broken down by modes of transport, road vehicles are responsible for around 75% of the related emissions with sea and air segments' inputs on the rise (IEA 2020). In tackling this, the International Maritime Organization (IMO) undertook a plan on reducing greenhouse gas (GHG) emissions from international shipping by at least 50% by 2050 (IMO 2020).

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Specifically, sustainability in transport and logistics has been fairly studied both from the operational and regulative sides (Dekker et al. 2012). As the world economy is shifting towards green, digital, cost-efficient and zero waste policies, as of today it is predominantly viewed from the supply chain perspective (Chu et al. 2017; Kazancoglu et al. 2018). For instance, sustainability in logistics operations already within the chain could be achieved by applying either a dual-channel supply approach (Barzinpour and Taki 2016) or cross-docking (Dulebenets 2018). Based on World Bank Logistics Performance Index (LPI) Lu et al. (2019) have empirically bridged logistics operations and environmental management by introducing a new metric—Environmental Logistics Performance Index (ELPI). Some scholars have referred to the phenomenon in question as a circular supply chain specifically centering it around *just-in-time* and *3R* (reduce/reuse/recycle) tools (Blomsma and Brennan 2017; Merli et al. 2018; De Angelis et al. 2018).

From the regulatory side climate provisions in regional trade agreements do also contribute to sustainability, including that in transport and logistics (Morin et al. 2018; Berger et al. 2020). Efficiency of the EU regional policy on transport has been tested on the basis of greenhouse emissions (Eliasson and Proost 2015). Being in the same vein, Georgatzi et al. (2020) have empirically investigated the effect of strengthening the environmental policy and green technologies related to transport on the CO2 emissions produced by the EU transport.

On their part, Morin and Jinnah (2018) have found 8 types of provisions in the existing preferential trade agreements (PTAs) with the promotion of renewable energy at the top. The EU pioneered this motion in 1991, and as of today there are, on average, 2.6 climate provisions in the EU trade agreements compared to 0.2 signed by others (Morin and Jinnah 2018). Moreover, there is a relative divergence in approaches undertaken by the EU and US when including environmental clauses in regional agreements. Unlike the EU with its inclusive and cooperative bases, the US forces its partners (fair for both North American Free Trade Agreement (NAFTA) and United States-Mexico-Canada Agreement (USMCA) formats) to introduce 'equally stringent environmental standards' and related regulations (Morin and Rochette 2017).

In its turn, sustainability of transport and logistics operations in North America has been relatively touched upon. For instance, Rodrigue and Notteboom (2010) scrutinized the existing logistics gateways in NAFTA from the perspective of location, functionality, management and regulation. Blank and Prentice (2015) studied the potential of autocabotage in shortening the empty run and, consequently, reducing greenhouse gas emissions.

Overall, there is a gap in the existing research, which the paper endeavors to critically cover. Specifically, this gap is prominent when studying the link between the environmental provisions of the USMCA that came into force on July 1, 2020 as a successor of NAFTA and greener transport in the region. In this essence, the research hypothesis states that the implementation of environmental agenda under the USMCA climate provisions and the liberalization of cabotage shipments across the United States, Canada and Mexico can reduce the region's ecological footprint and add sustainability to their transport.

2 Methodology

The research methodology is twofold. First, its theoretical grounds could be found in the concepts of environmental economics, circular economics, climate governance and regional integration under the umbrella of sustainability paradigm. In neoclassical traditions environmental economics generally deals with the 'market failure' phenomenon. Circular economics refers to an economic system containing material flows with zero waste philosophy. Climate governance and regional integration could be applied when viewing environmental provisions (that imply green initiatives in transport and logistics) of regional trade agreements as one of the most decisive non-trade dimensions of economic integration.

Second, it embraces a profound analysis of primary and secondary sources presented in a form of literature review. The review is holistic, comparative, multidisciplinary and critical with the fundamental aim of investigating ideals and realities of sustainability in transport and logistics both worldwide and in North America in particular.

3 Results

It has been revealed that North America is responsible for a sizeable and relatively adverse environmental impact broken down to multiple measurements, i.e. carbon dioxide emissions, waste management, marine litter, food loss and waste. The region's performance on the environmental agenda is uneven across the studied dimensions, yet, it remains relatively competitive compared to others.

In 2019 North America accounted for 17.5% (–2.8% compared to 2018) of the total world carbon dioxide emissions (most prevalent among greenhouse gases) well ahead of Europe (12.0%). In its turn, the US generates almost 83% of the overall regional emissions, Canada—9.3% and Mexico—7.6% (BP, 2020). Although the 3 economies constitute 27.8% of the world GDP, their CO_2 emissions are around 17.0% of the total world carbon dioxide emissions. In contrast, China with its global GDP share of 16.0% alone is responsible for close to 30.0% of the related emissions.

However, if judged by the Environmental Logistics Performance Index (Lu et al. 2019), which in addition to the World Bank's Logistics Performance Index (LPI) methodology considers energy consumption and CO_2 emissions of transport, the US and Canada have leveled at close to 0.9 (on the index scale from 0 to 1), which indicatively shows the eco-friendliness of their transportation. Thus, Lu et al. (2019) refer to North America as a high-performance region well ahead of East Asia and Pacific, Europe and Central Asia, South Asia and Latin America.

Regarding the dimension of waste management measured by the municipal solid waste (MSW) North America has been found to underperform in reducing its waste footprint. Thus, the United States, Canada and Mexico's shares in global MSW exceed their shares in the world's population. Specifically, the US is responsible for 12.0% of the global municipal waste (773 kilograms of waste per capita) when accounting for only 4.0% of the global population; Canada for 1.7 and 0.3% respectively; Mexico for 2.1 and 1.9% respectively (Verisk Maplecroft 2019, p. 5). Furthermore, the countries in question are severely lagging behind in recycling performance in contrast to others. For example, the Americans produce 3 times more waste than the Chinese, while recycling only 35% of MSW, unlike the second to none Germans with the recycling record of 68% (Verisk Maplecroft 2019, p. 6).

Another dimension of the North American ecological profile is marine litter. The Pacific waters to the west of the continent are home to the largest offshore plastic accumulation zone in the world—the Great Pacific garbage patch. With its eastern part located between the Hawaii and California the patch is estimated to cover a surface area of 1.6 million square kilometers accumulating (by the median prediction) 79,000 tonnes of marine plastic (Lebreton et al. 2018, p. 7). The patch is up to half composed of fishing nets and includes 8% microplastics that pose a special threat to the marine life and the subsequent natural food chains.

Finally, the region is also facing the problem of food loss and waste. Whereas food waste is naturally attributed to spoilage or neglect, food loss could be associated with insufficient methods in production and the relative inefficiency within the supply chains. Overall, the North American states annually generate around 168 million tonnes of food loss and waste. Broken down to states, such a loss is estimated at 126 million tonnes in the United States, 28 million tonnes in Mexico and 13 million tonnes in Canada (CEC 2017, p. 12). The US and Canada account for the highest rates of food loss and waste per person annually: 415 and 396 kilograms respectively (CEC 2017, p. 12). The corresponding figure for Mexico is relatively lower leveled at 249 kilograms per capita, which corresponds to the average in developing economies.

Apart from measuring the ecological footprint of the region from the national perspective it is worth undertaking a corporate approach. As of today, corporate environmental contribution is also being evaluated from the supply chain perspective. For instance, Greenhouse Gas Protocol provides companies with corporate standards to assess and report their direct and indirect environmental impact. The emissions have been grouped into three scopes (GHG Protocol 2020). Scope 1 implies direct emissions from the company's operations. Scope 2 deals with the indirect impact from consumption of energy resources. Scope 3 embraces indirect emissions from operations within the supply chain of the company, including those both in the upstream and downstream segments. Normally emissions amounting from these segments are on average 5.5 times higher than those produced from owned or controlled sources. Depending on the industry upstream and downstream emissions range from 1.3 times higher for companies in power generation and materials industries to 10.9 times higher for companies in retail. Fossil fuels industry is the only emission-intensive exception where the companies' counterparts generate only 0.4 times the amount of the in-house emissions (CDP 2019, p. 18).

According to EcoVadis (2020) estimates on corporate sustainability performance, Europe outperforms North America on energy and emissions advancement, although the latter is the global leader in emissions reporting. These estimates back up the evidence from companies reporting to Carbon Disclosure Project (CDP) on greenhouse gas emissions and to the United Nations Global Compact (UNGC) initiatives on the corporate progress under the SDGs. Unlike the world trend in sustainability assessment with large companies underperforming environmentally in North America large companies perform 17% better than small and medium companies under sustainable procurement category and 6% better under environment (EcoVadis 2020).

Thus, sustainability in supply chains (and consequently in transportation) could be reached with the introduction of circularity. The concept of circularity involves three stages. First stage implies introduction of sustainable material management and responsible product design for future circular usage. Second –optimization of suppliers' processes with sustainability in mind and optimization of the linking logistics components. Third—reusing and remanufacturing coupled with return, buyback policies, remarketing and, ultimately, recycling. These steps mark the full circle in a circular supply chain. The concept of circularity could be also viewed as the unified embodiment of industry 4.0 advancements applied in logistics and transportation.

Under this framework logistics and transport operations represent a vital component of any supply chain. The research comes up with parameters the development of which may facilitate the achievement of sustainability in logistics and transportation in North America. Ecologically addressed logistics parameters include but are not limited to: mode of transportation, fuel used, and induced optimization of distance traveled. It is worth stressing that the development of these dimensions is underway in North America, yet, it faces problems mainly of regulatory origin.

North American supply chains benefit from the expansive and elaborate logistics gateways on all transport modes. Simultaneously, transportation is one of the main sectors contributing to the amount of greenhouse gas emissions generated by the USMCA states. In 2018 it was responsible for the largest share of 28% in the overall US emissions with CO_2 accounting for 97.2% in total emissions well ahead of other greenhouse gases (EPA 2020, p. 1). Road transport dominant in both US domestic and overall regional freight-turnover structures generates an overwhelming share of GHG emissions (Table 1).

As it could be seen from the table, water transport is underutilized in the US domestic freight, whereas in the regional trade through American ports it accounts for the majority of weight transported. The environmental impact of

Table 1 Shares of selected transport modes in transportation-induced greenhouse gas emissions, US domestic freight and intra-USMCA cargo carriage in 2018–2020, per cent

Mode	*Share in US transport GHG emissions*	*Share in US domestic transported weight*	*Share in US domestic transported value*	*Share in intra-USMCA cargo carriage weight*	*Share in intra-USMCA cargo carriage value*
Truck	23.0[a]	64.0	69.8	18.9	64.3
Rail	2.0	9.6	3.9	16.5	13.9
Water	2.0	4.5	2.3	35.1	7.1
Air	9.0	0.03	3.3	0.1	4.4

[a]This share refers to medium- and heavy-duty trucks that are more frequently involved in cargo transportation in the United States. However, when put together with light-duty vehicles road transport accounts for 82% in the overall US GHG emissions

Source Compiled by the authors based on: United States Environmental Protection Agency. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZK4P.pdf; Centre for Transportation Analysis. Available at: https://faf.ornl.gov/faf4/Extraction1.aspx; U.S. Bureau of Transportation Statistics. Available at: https://explore.dot.gov/t/BTS/views/Dashboard_PortbyCommodity/Last12MonthsofTrade

air transport is disproportionate both to the weight and value of the underlying cargo in the domestic US and regional traffic.

The type of fuel used could be named as another sustainability-oriented parameter for North America. Under the IMO emission standard effective from January 1, 2020 sulfur content in bunker fuel is to be reduced to 0.5% by mass globally, except for 4 designated Emission Control Areas (ECA) where it has already been limited to 0.1% ahead of the curve since 2015 (IMO 2020). Two out of the four areas embrace the waters of North America: the North American Control Area (waters up to 200 nautical miles off the West, East, and Gulf coasts of Canada and the US, French territories, and the Hawaiian Islands) and the United States Caribbean Emission Control Area (waters up to 40 nautical miles off Puerto Rico and the U.S. Virgin Islands).

The regulation in question allows the use of exhaust-gas cleaning devices in shipping referred to as 'scrubbers' that enable the carriage for combustion of non-compliant sulfur-heavy fuel in ECAs and elsewhere. However, in July 2009 California introduced its own, stricter regulation for vessels fuel within 24 nautical miles of the California baseline. Specifically, California Air Resources Board Ocean-Going Vessel (CARB OGV) Fuel Regulation demands the use of marine distillate grade fuels (marine gas oil or marine diesel oil) and no scrubbers in Californian waters (CARB 2020). Thus, the United States turn out to be performing better than Canada and Mexico when tracing the type of fuel used.

In optimizing logistics operations across the USMCA from the perspective of smartness, greater connectivity and eco-friendliness the countries face common obstacles related to cabotage rights. Cabotage implies the carriage of domestic traffic between points within a single country by a foreign carrier. Such activities constitute a domestic service falling under domestic regulation that protects the national interest. Canada, the United States, and Mexico all generally (with several exceptions and waivers for force majeure) prohibit cabotage in their territories in water, road and air transportation of passengers and cargo.

Discussions on the prospects of maritime transportation in North America inevitably lead to the 'Cargo preference' laws and the Jones Act (Sect. 27 of the Merchant Marine Act, 1920) of the United States. Under the 'cargo preference' package passed in 1904–1954, seaborne shipments of all military cargo and 50% of non-military cargo purchased with federal funds are to be done by vessels under the US flag (U.S. Department of Transportation 2018).

In its turn, the Jones Act is commonly considered to be the most vivid example of protectionism in transportation. By the law any commercial marine carriage between points in the US could be done only by a US-built and US-registered vessel, owned and crewed by the US citizens (CRS 2019a). Today, the law stands still to support the national shipping and shipbuilding, although the economic efficiency of these measures is debated. According to the US Maritime Administration (MARAD) estimates, daily operating costs of container and roll-on/roll-off vessels that constitute around 75% of the US-flag foreign trade fleet are 2.2 and 3.3 times respectively greater than those of the vessels under the foreign flag (MARAD 2011).

The Act has several noticeable environmental implications that could contribute to greater sustainability in regional transportation. As found in Table 1, maritime transportation is relatively emission-neutral compared to road and rail. Indeed, it generates less GHG emissions. However, it is responsible for up to 10 times more criteria air pollutants, i.e. sulfur oxides (SOx), nitrogen oxides (NOx), particulate matter (PM), yet, for instance, SOx segment has been already fixed by IMO's ECAs (Fitzgerald 2020). Meanwhile, the underutilization of water transport in the US domestic traffic is largely attributed to the higher costs of the marine transportation under Jones Act, which explains the shippers' switch to other transport modes. Simultaneously, Fitzgerald (2020) acknowledges that there is an uncertainty among scholars about the magnitude of the environmental costs of marine transport. Yet, under his scenario with Jones Act's abandonment, where both new vessels enter the US fleet and part of truck and rail's freight shifts to water transport, the potential net reduction in environmental costs can range between $109 million and $8.2 billion.

Besides, the Act affects the configuration of supply chains and the promotion of renewables, namely wind turbines for offshore wind energy farms. As the installation of the turbines requires unique 'wind turbine (tower) installation vessels', a company in the renewable energy industry has two options in terms of transportation. It can either charter a single foreign-flagged vessel to carry the turbines from abroad and install them; or two vessels, one Jones Act-compliant carrier and a foreign non-compliant installation vessel. To facilitate the development of renewable energy off the US coast, the first Jones Act-compliant fleet in question was initially planned for end 2019 but was later postponed until 2023 (CRS 2019a).

The case of the US is given here to exemplify the general implications of competition restrictions on cabotage, and as similar laws do exist in Canada and Mexico they are highly destined to experience equivalent effects of the potential relaxation. For instance, since the elimination of a 25% tariff in 2010 with no vessels imported before Canada has seen a surge of at least 35 new vessels built for navigation on the Great Lakes (CRS 2019a).

Overall, general exceptions from maritime cabotage restrictions in North America include seaborne carriage of deadhead (empty) containers between domestic ports. In its turn, Mexico's policy is more selective. Thus, it allows foreign-flag carriers to obtain renewable fixed-term cabotage permits in case of shortage of suitable bulk vessels under the national flag. As OECD (2017, p. 149) estimates it, cabotage in this case accounts for one third of the total volume of the country's domestic shipping.

Shared intra-regional and domestic road transportation has remained a controversial issue since the enactment of NAFTA. The US-Mexico clauses that were supposed to gradually allow Mexican trucks onto American roads for long-haul international routes (not even cabotage) starting from 1995 were not fully implemented until 2015. The potential liberalization was confronted by influential trade unions such as The International Brotherhood of Teamsters and The Owner–Operator Independent Drivers Association. The unions forced protectionism under the pretext of Mexican carriers' non-compliance with safety and environmental standards, risk of unauthorized migration as well as possible contraband.

Normally, the cross-border carriage by road is limited to the commercial-zone areas within 25 miles from the US-Mexican border. A common logistics configuration in this case includes unloading at a warehouse within the commercial zone or transshipment onto a truck of a national carrier. After a two-decade delay, in 2015 Mexican motor carrier companies were finally allowed to obtain Federal Motor Carrier Safety Administration (FMCSA) authorizations for long-haul international operations beyond the 25-mile area.

To some degree road cabotage is permitted in Canada. A foreign vehicle may conduct a cabotage carriage in Canada if this carriage is 'incidental' under the international shipment, i.e. direct or return moves, except for in-transit trips involving Alaska. For instance, such incidental domestic freight does not exceed 30% of the total truck load (Blank and Prentice 2015). However, there is no reciprocity for Canadian drivers in the US. While its customs regulations imply the similar 'incidental' term legislation on migration creates a deadlock prescribing that 'purely domestic service or solicitation, in competition with the United States operators, is not permitted' (Federal Register 2020).

In the airline sector cabotage traffic rights may be provided under the 8th and 9th International Civil Aviation Organization (ICAO) freedoms of the air. These freedoms establish consecutive cabotage that includes a leg to/from airline's originating country and standalone (purely domestic) cabotage respectively. According to the bilateral Open Skies agreements between the US, Canada and Mexico, these traffic rights are reserved for the national carriers, which is in line with the global practices. Minor exceptions concern international charter flights carrying passengers and private non-revenue flights.

Thus, North America performs relatively well from the perspective of ecologically addressed parameters applied. However, the absence of a full-fledged cabotage policy on maritime and road modes prevents the configuration of efficiently optimized logistics solutions across North America. Besides, it limits coastal shipping and cost-effective land transshipment solutions that taken together could lead to the reduction in CO2 emissions and, consequently, raise the sustainability of the region's transportation.

4 Conclusion

Overall, the paper concludes that the shift towards greener transport in North America is on the way. From the theoretical side the concept of circularity has the potential to incorporate the advancements of industry 4.0 applied to logistics and transportation. Its contribution to the development of greener transport in North America has been measured by the following ecologically addressed logistics parameters: mode of transportation, fuel used, smart logistics, optimization of distance traveled. Related implications on the corporate level have resulted in regional companies leading both in reports on emissions and optimization policies on supply chains.

Yet, the region's progress in transport sustainability is uneven. On the one hand, a unique approach to ECAs present in North America demonstrates a breakthrough in the promotion of advanced environmental standards in shipping (i.e. in sulfur content terms) well ahead of global trends. On the other – the US, Canadian and Mexican national regulations generally restrict cabotage operations on major transport modes (i.e. maritime and road) across North America. Such protectionism mostly vivid in the US case is believed to limit the potential of greener initiatives in the regions' transportation.

The research believes that the environmental provisions of the USMCA could be a good institutional springboard for the United States, Canada and Mexico's motion towards sustainability in transport, though the agreement does not specifically address crucial sustainability matters.

From the institutional perspective, out of the three the US has the most prominent position on environmental provisions in trade agreements. Its stance has drastically evolved since 1980-s from placing such provisions subordinate to trade to eventually encouraging legal adherence to the multilateral environmental agreements (MEAs) the signatories are parties to. Under the bipartisan agreement of 2007 and Trade Promotion Authority (TPA) passed in 2015, the US president has been empowered to negotiate international trade agreements and, consequently, has pursued the implementation of MEAs into such treaties (CRS 2019b). Besides, non-derogation from domestic environmental laws and their bona-fide enforcement have been strictly demanded from the signatories.

Canada holds a less sound but compatible view on environmental provisions in trade agreements. Like the US it views loose compliance with undertaken environmental obligations as a dishonest gain of competitive advantage in international trade pledging to contest such cases. The related Mexico's position is the least pronounced in the region. It has not undertaken significant commitments on sustainability outside the agreements that involve its North American partners.

In a nutshell, the environmental part of the USMCA significantly builds on NAFTA and specifically its side agreement—North American Agreement on Environmental Cooperation (NAAEC). The environmental provisions previously contained in the side agreement have now been incorporated into the body as chapter "Ecological Vector of Social Responsibility in Energy Companies" 'Environment'. Such a decisive step has made them subject to built-in dispute resolution procedures and stringent legal actions pertaining to possible violations.

All seven MEAs[1] specified by the United States as basic priority under the TPA-15 are listed in the USMCA (Article 24.8), but the United Nations Framework Convention on Climate Change (UNFCC) also known for the related Paris Agreement, has been left out. Three out of the seven MEAs (i.e. Montreal Protocol, MARPOL, CITES) were respectively emphasized in the articles on the protection of the ozone layer, protection of the marine environment from ship pollution, and on wildlife. Additional attention is given to the conservation of marine species, management of fisheries and subsidizing them, all in line with the corresponding international treaties (Articles 24.17–24.21). Thus, the implications of at least two MEAs—MARPOL and the Montreal Protocol—could be directly executed in the greener transport agenda for North America.

The agreement has also introduced brand new environmental provisions, two of which are binding: on the criminal prosecution of wild fauna and flora trafficking; and on the reduction of marine litter (including plastic litter and microplastics). Another novelty is an intention stated in the Environmental Cooperation Agreement (ECA), a new side agreement between the United States, Canada and Mexico that superseded NAAEC: 'promoting sustainable

[1] Convention on International Trade in Endangered Species (CITES), The Montreal Protocol on Substances that Deplete the Ozone Layer, The International Convention for the Prevention of Pollution from Ships (MARPOL), The RAMSAR Convention on Wetlands, The Convention on the Conservation of Antarctic Marine Living Resources (CAMLR), The International Convention for the Regulation of Whaling (ICRW), and The Inter-American Tropical Tuna Commission (IATTC).

production and consumption, including reducing food loss and food waste' (ECA 2018). So, reducing marine litter and food loss could be also regarded as sustainable transport milestones for North America, as the region is severely underperforming on this track.

Besides, two former debated measures generally hampering the greener motion in transport have not been transferred into the main body of the agreement. First, the notorious NAFTA's proportionality clause for energy exports has been abrogated. For instance, this obligation limited Canada's eco-friendliness, as the state was compelled to maintain its energy exports to the US at the level of previous three years (while energy extraction in Canada generates more GHG emissions than consumption). Second, the USMCA regulation has granted the governments an opportunity to protect national interests when settling the disputes with investors from the member states, as previously numerous environmental cases were resolved in favor of such investors.

At the same time, the USMCA is not deprived of a number of failing points in transport sustainability. Given the binding nature of the new agreement, the US unilaterally reserves the right to limit the issuance of the previously discussed FMCSA authorizations for long-haul operations to Mexican carriers. Such limitations can take effect if the US identifies material harm or threat of it to US trucking companies and drivers. Specifically, such material harm implies a 'significant loss' of market share starting from July 1, 2020. Since this unilaterally held condition lacks precision, it may be used arbitrarily. Thus, as of end 2020, under the previous regime sixty-six Mexico-domiciled motor carriers got authorizations from FMCSA and no limitations on 'significant losses' have been exercised under the USMCA yet (FMCSA 2020).

In its turn, cooperative activities laid down in ECA include the promotion of 'all clean energy sources' and 'low emissions development' (ECA 2018, p. 7). However, neither chapter "Ecological Vector of Social Responsibility in Energy Companies" nor the ECA contain such salient terms of the environmental agenda as climate change, greenhouse gases, or renewable energy. Additionally, the activities under the ECA bear rather an advisory nature in contrast to the binding nature of provisions secured in the USMCA.

Thus, the research believes that the USMCA environmental provisions can become a part of a wider regulatory basis for greener transport, which coupled with liberalization of cabotage shipments across North America could improve the ecological footprint of the region. Yet, this motion towards sustainability is heavily subject to mutual concessions of policy-makers in the United States, Canada and Mexico.

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Digital Technologies in the Oil and Gas Sector and Their Contribution to UN Climate Action Goal

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1 Introduction

Nowadays, climate change poses one of the most discussed issues by the world community. Goal 13, "Take urgent action to combat climate change and its impacts", belongs to the 17 Sustainable Development Goals that all UN member states have agreed to achieve by 2030. The goal comes down to reduction of carbon dioxide (CO2) and other greenhouse gases emissions into the atmosphere, which would help to contain global warming (UN 2017). The Paris Climate Agreement signed back in 2015, aims at strengthening measures to combat the threat of climate change and to determine the contribution of each participating country to reducing emissions.

To the greatest extent, the problem of climate change is associated with the activities of oil and gas companies, that provide a significant contribution to the volume of harmful substances emitted into the environment. For example, according to the World Energy Agency, methane emissions in the global oil and gas industry account for about 14% of global emissions and 24% of anthropogenic emissions of this greenhouse gas (Analytical Center for the Government of the Russian Federation 2020). Accordingly, these companies consider the climate action goal as one of their priorities. To achieve it, they have already begun to apply a number of measures, including those related to digital technologies.

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2 Methodology

The authors studied a number of sources on the aspect under study, which made it possible to identify existing approaches and make original suggestions on the issue. Broadly speaking, digital technologies can be used not only to improve the efficiency of the production activities of oil and gas companies, but can also help them realize the goals of sustainable development, in particular the Climate Action Goal.

The main sectors, problems and prospects for the introduction of digital technologies in the operating and economic activities of international oil and gas companies have already been widely studied in the works of foreign and Russian authors (Cann and Goydan 2019; Suloeva and Martynatov 2019; Khodkovskaya and Stoyaltseva 2018; Peskova et al. 2018).

A number of scientists also highlight the issues of digital technologies implementation as instrument to ensure sustainable development of companies in general, and the oil and gas complex, in particular (Zavyalova and Starikova 2018; Bobylev et al. 2018; Daneeva 2019; Lomachenko 2020; Sheveleva and Zagrebelnaya 2020).

However, it should be noted that in the above works, digitalization is considered solely in terms of increasing the efficiency of production activities and there is no segmentation of this process by SDGs. At the same time, the problem of analyzing the role of digital technologies in the implementation of Climate Action SDG by international oil and gas companies remains almost unexplored. In this regard, the authors of this article put forward the assumption that digital technologies can allow oil and gas companies to solve the problem of climate change in a strategic perspective.

The application of the systematic approach provided for a comprehensive study of a number of disparate aspects that had previously been analyzed separately. This way, the authors managed to carry out a complex study of digitalization, sustainable development goals, climate action and the environmental aspects of the oil and gas companies' operating activity.

The analysis has led to the conclusion that digital technologies indeed make a positive contribution to reducing emissions into the environment by oil and gas companies.

Thanks to the methods of generalization and synthesis of the obtained data, the authors made several conclusions, which could be relevant in the process of oil & gas companies' strategic planning.

3 Results

According to a study by PricewaterhouseCoopers (1141 companies from 31 countries and 7 industries participated), SDG #13 ('Climate Action', conceived to facilitate the inclusion of measures to preserve the climate, increase business resilience to climate risks, as well as reduce emissions of greenhouse gases and other harmful substances into the atmosphere into the strategic business plans) is ranked second in the business strategies of participating companies. At the same time, the fuel and energy complex and the extractive industry companies, primarily oil and gas enterprises, put this goal in the first place (Table 1).

This conjuncture is due to the necessity for oil and gas companies to comply with the requirements set by international organizations that regulate greenhouse gas emissions, primarily carbon dioxide (CO2) and methane (CH4).

In 2010, the Global Methane Initiative (GMI) was launched to stimulate stronger action to tackle climate change while developing clean energy sources. In 2012, with the support of the United Nations Environment Program (UNEP), the Climate and Clean Air Coalition (CCAC) was created, whereby countries agreed to accelerate efforts to reduce short-term climate pollutants. Within the coalition, the Oil & Gas Methane Partnership (OGMP) was launched in 2014 to help span the corporate level. Also in 2014, the Oil and Gas Climate Initiative (OGCI) was started, encouraging oil and gas companies to take collective action to combat climate change and intensify the global response. In 2015, the Paris Climate Agreement was adopted, aiming to reduce CO2 emissions into the atmosphere from 2020 on. To further reduce methane emissions, improve the efficiency of these efforts at all links of the gas industry value chain, and provide more accurate data on emissions, the Guidelines for Reducing Methane Emissions in the Natural Gas Supply Chain were published in 2017. In2019, the Global Methane Alliance was created to ensure that countries develop their national commitments to reduce methane emissions from the oil and gas industry.

In 2020, member companies of the Oil and Gas Climate Initiative set a target to reduce the average carbon intensity of oil and gas production operations to 20–21 kg of carbon dioxide equivalent per barrel of oil equivalent (CO2e/boe) by 2025 from a baseline of 23 kg in 2017. This target represents a reduction of 36–52 million tonnes of CO2-eq per year by 2025, assuming constant oil and gas production volume. The target includes reductions in both CO2 and methane emissions from oil and gas exploration and production activities. Emission rates are to be calculated as the proportion of oil and gas commercially available.

In order to achieve the above indicators, oil and gas companies, first of all, update existing and install additional equipment to identify and stop leakages. However, recently, with the fourth industrial revolution in place, it has become possible to use digital technologies, in particular, Big Data, Machine Learning and AI, 3D printing, cognitive analytics, the Internet of things, robots, digital twins (including visualization), blockchain etc. in order to combat climate change (Sheveleva and Zagrebelnaya 2020).

Having realized the urgency of this problem, major oil and gas companies have already begun to implement such technologies into their practice in order to reduce greenhouse gas emissions.

Table 1 Industry selection of sustainable development goals

	Global Total	Consumer markets	Energy utilities & resources	Financial services	Industrial manufacturing & automotive	Technology, media & telecoms
1	8 Decent work and economic growth	8 Decent work and economic growth	13 Climate action	8 Decent work and economic growth	8 Decent work and economic growth	8 Decent work and economic growth
2	13 Climate action	12 Responsible consumption and production	8 Decent work and economic growth	13 Climate action	12 Responsible consumption and production	13 Climate action
3	12 Responsible consumption and production	13 Climate action	7 Affordable and clean energy	4 Quality education	13 Climate action	4 Quality education
4	3 Good health and well-being	3 Good health and well-being	9 Industry, innovation and infrastructure	5 Gender equality	3 Good health and well-being 9 Industry, innovation and infrastructure	9 Industry, innovation and infrastructure 12 Responsible consumption and production
5	9 Industry, innovation and infrastructure	6 Clean water and sanitation	12 Responsible consumption and production	9 Industry, innovation and infrastructure		

Source PricewaterhouseCoopers Sustainable Development Goals Challenge 2019—https://www.pwc.com/gx/en/sustainability/SDG/sdg-2019.pdf

In 2017, the British oil and gas company BP signed an agreement with the American software company Microsoft, under which all BP data was transferred to a cloud platform, where it has been being processed by Microsoft tools to provide for visualization, forecasting, machine learning and data analytics enabling BP to improve optimization and transformation of core business processes, which should lead to a reduction in the company's carbon footprint. Together, the companies are planning to create an ecosystem of low-carbon technologies that will capture, utilize and store carbon in order to prevent or at least reduce emissions.

In September 2020, BP and Microsoft also signed a strategic agreement that aimed at expanding the digital transformation of energy systems and reducing carbon emissions.

British-Dutch oil and gas company Shell is also actively collaborating with the US company Microsoft in the field of digital technologies that contribute to the fight against greenhouse gas emissions. In September 2020, to achieve this goal, they formed a strategic alliance that should result in them reaching zero emissions by 2050.

As part of the alliance, Shell and Microsoft are going to continue their collaboration to transform business operations with artificial intelligence. Shell's real-time access to analytic data improves the safety of employees and equipment, which in turn leads to a reduction in carbon dioxide emissions.

In addition, the partnership with Microsoft enables Shell to offer its suppliers and customers support to reduce their carbon footprint.

In March 2020, Shell entered into an agreement with the Norwegian energy company Equinor, under which they are planning to develop digital technologies, primarily Big Data, artificial intelligence and 3D printing. The development of joint digital innovations will contribute to improving the production process, ensuring the efficiency of supply chain management, increasing the level of safety, which ultimately could significantly reduce carbon dioxide emissions into the atmosphere.

Also, Shell has set up a research center where scientists at the University of Southampton are working to optimize energy use and reduce harmful emissions in maritime shipping using systems based on digital and technological innovation. The developed machine learning algorithms that optimize the hydrodynamic operation of ships should allow the company to achieve the UN goal by 2050 and achieve a 50% reduction in greenhouse gas emissions in maritime shipping.

In September 2020, the American Rocky Mountain Institute[1] developed a new technology platform that combines data and artificial intelligence to help oil and gas companies get a more accurate information on greenhouse gas and methane emissions, as well as provide a unified reporting. ExxonMobil, Chevron, Origin Energy and Shell plan to implement this platform at their

[1] A not-for-profit organization headquartered in Basalt, Colorado, USA that conducts research in renewable energy, energy efficiency and energy storage.

fields in Texas to simulate different scenarios of pollution reduction programs, which depend on the carbon tax rate and the strength of hurricanes or floods.

In September 2020, the Austrian oil and gas company OMV outlined plans to create a digital twin for its Schwechat refinery, which will optimize the preheating line at its crude vacuum distillation unit, leading to a 20% reduction in CO2 emissions by 2025 (100% by 2050).

Russia's largest oil and gas companies are also starting to use digital technologies to reduce their greenhouse gas emissions.

PJSC NK Rosneft, fulfilling its development strategy until 2022, as well as catering for the provisions of the UN Global Compact, to which it is a party, is implementing a corporate automated system for calculating greenhouse gas emissions into its operations in an effort to reduce the impact of its production and other economic activities on climate. This system enables the company to recognize greenhouse gas emissions efficiently, which in turn allows a timely and more efficient implementation of mechanisms and tools that stimulate their reduction.

PJSC LUKOIL is introducing digital development programs in the downstream business segment, primarily aimed at improving the efficiency and reliability of equipment and ensuring environmental impact control.

Gazprom Neft is implementing a digital production management system at its refinery in Omsk. Thanks to the installation of 4,000 sensors, it is now possible to automatically collect and process information about the main indicators of the plant's operations, track changes and prevent emergencies.

The Transneft Company has automated the processes associated with the transportation of oil and oil products, as well as the operation of trunk pipelines. A unified dispatch control system of the pipeline system was launched, which is supposed to facilitate prompt response in case of unacceptable changes in pumping parameters, reduce the risk of emergencies, and, accordingly, reduce possible emissions into the atmosphere.

Thus, it can be concluded that digital technologies of international oil and gas companies play an important role in the implementation of the 'Climate action' SDG, representing a tool for both reducing the negative impact on the environment and a preventive measure to prevent possible emissions of harmful substances into the atmosphere (Table 2).

Artificial intelligence technologies help to improve the efficiency of preventive maintenance of equipment, as well as more rational and efficient repair.

Cognitive analytics provide better and more objective predictions, impact assessments, recommendations and assumptions, thus providing a holistic view of an oil and gas company, from functional intelligence to cumulative impact, including oil deposits, wells and surface equipment. As a result, oil and gas companies can operate more efficiently, learn and improve continually.

The Internet of Things facilitates real-time communication and remote control of sensors, devices and equipment of an oil and gas company, which helps to obtain real-time analytical information, predict and prevent problems and disruptions before they occur.

Table 2 Role of digital technologies of international oil and gas companies in the fight against climate change

Prevention measures		*Negative impact on the environment reduction*	
Digital technology	*Effect*	*Digital technology*	*Effect*
AI	Identifies the risk of accidents, adjusts production processes	Low carbon technology ecosystem	Technologies to capture, recycle and store carbon
Cognitive analytics	Provides more efficient planning and forecasting of activities	Machine learning algorithms	Optimizes equipment operation, which minimizes emissions
The Internet of Things	Remote access to equipment, correction of possible violations and deviations	Technology platform, connected data and artificial intelligence	Obtaining accurate information on emissions, monitoring their reduction, unified reporting on their volumes
Digital 'twins'	Visualization of the production process, elimination of possible problems	Corporate automated system for calculating emissions	Operational accounting of emissions and implementation of mechanisms to reduce them
General Dispatch Control System	Prompt response, reducing the risk of emergencies	General Dispatch Control System	Reducing potential emissions

Sources Compiled by the authors based on the results of the study

Digital twin technologies, due to modeling capabilities, testing and implementation effect assessment, allow to visualize updates, as well as to optimize production systems, equipment and human resources.

In general, digital technologies help oil and gas companies to quickly obtain valuable information, improve the analysis efficiency of existing unstructured and new data, as well as expand analytical capabilities and improve awareness of the current situation.

With digital technologies, oil and gas companies can carry out advanced diagnostics of equipment and business processes, which allows early or timely detection of system failures or errors in production and economic activities facilitating taking the most effective decisions, and avoid or prevent leaks and accidents that can lead to emissions of greenhouse gases into the atmosphere.

4 Conclusions

One of the most pressing problems of modern society and a necessary condition for its sustainable development is the problem of climate change. Being one of the largest sources of air pollution, oil and gas companies are beginning to engage actively in solving this problem and have been including measures aimed at implementing the UN #13 'Climate Action' SDG ("Take urgent action to combat climate change and its consequences") into their development programs and strategies. The largest international oil and gas companies are considering making use of digitalization as one of such steps.

In recent years, such major international oil and gas companies as BP, Shell, Equinor, ExxonMobil, Chevron and Origin Energy, OMV, as well as Russian Rosneft, LUKOIL, Gazprom Neft and Transneft, have begun to actively implement digital technologies to combat climate change. The plan has been to reduce CO2 and other greenhouse gases footprint significantly in the near future, reaching zero emissions in a strategic perspective.

Analysis of practices of digital technologies' implementation by the largest international oil and gas companies has showed that, thanks to digitalization, it has become possible to control devices and equipment remotely in real time, which, in turn, contributes to obtaining operational analytical information, predicting and preventing problems and failures before they occur, which, in turn, helps to avoid or prevents leaks and accidents that can lead to the release of greenhouse gases into the atmosphere.

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Digital Technologies to Combat Climate Change in the Economy of the Future Through Industry 4.0

The Influence of Digitalization on Chinese Banks: New Financial Technologies in a Plan Economy (Including Shadow Banking and Green Fintech)

Damir A. Abdullaev, Irina J. Rassolova, and Nursafa G. Khairullina

1 Introduction

The Chinese banking system is interesting for research for a number of reasons: first, it represents a successful system, consisting of large banks, in a planned economy which is tightly regulated. Second, many Chinese banks (CNBC, ExIm Bank of China and others) (Calkins 2013; Shu et al. 2019) became transnational banks, despite opposition from the traditional major players in the market (American and European TNBs). Third, it is believed that the planned economy is inflexible, so it can be supposed it adapts to new realities slowly, wherein digitalization, especially in banking and financial technology, requires great adaptability for any bank. That's why it is very interesting what the prospects Chinese banks have and what they are doing to survive in a rapidly transforming world and a changing market landscape.

Special attention should be paid to the problem of shadow banking, which is considered to be developed in China (Chui and Upper 2017). The main

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question is how new technologies will affect this sector, how it will change, and whether it will become completely digital, having gone into a slightly different space (both in the regulatory and in the physical sense). At the same time, it seems relevant to highlight what is meant by digitalization in the banking sector and to give its main differences from fintech. This is important because a number of large journals (Ernst & Young 2020; Forest and Rose 2015) consider these concepts to be close or even identical, which is true, but it is so only for the banking services end-user.

It is also necessary to notice that China has one of the most powerful banking systems among developing countries and this sector expansion to less developed countries, especially in Africa and Asia, causes the world community's worries as there is the market loss for its TNBs, but also due to a lack of confidence in China's banking sector's security and stability. All these factors make the research dedicated to the Chinese banking market extremely relevant.

2 Methodology

First, it is necessary to understand the meanings of digitalization and fintech terms which are interrelated, but they are fundamentally different concepts. As mentioned earlier, these two phenomena for the final consumer look the same, but they should be understood differently (Fig. 1).

The second issue considered in the article is the PRC banking sector's present and future. To research this issue, it is necessary to evaluate the digitalization role in the PRC economy from the viewpoint of where it comes from: whether it comes from inside or it is an element borrowed from foreign companies. That's why the authors divide digitalization into internal and external. In addition, the authors conduct a regression analysis of the foreign banks' role in the Chinese economy; through this analysis, it is proved that the PRC economic system differs that digitalization from the inside and from the outside are harmoniously combined in it.

Fig. 1 Differences between digitalization and fintech (Developed by the authors)

The third stage of the research is the study of shadow banks in the PRC: using this basis, the authors develop recommendations for the further digitalization development in the PRC banking sector, taking into account the need to reduce the shadow banks' role. An empirical shadow banking' research is based on a sector's statistical analysis, made by BIS.

2.1 Chinese Banks Prospects and Adaptivity

For the Chinese banking market, innovativeness, directed from the inside, is not characteristic. This is due to the fact that for a long time the financial services market, including banking, was regulated by the state and innovations in this area were not needed, as the financial technologies development was associated with increased risks, and it was also associated with increased corporate profits; this situation within the planned economy is disadvantageous to the main beneficiary which is the state. Nevertheless, recently a high degree of the financial sector and the economy's interdependence has created the need for more advanced financial instruments; the society's technological development and an access level increase for Chinese people to information created the need to suit to the current realities and to stimulate economic development through domestic demand (Gupta and Xia 2018—A paradigm shift in banking: Unfolding Asia's fintech adventures). The Internet merchants companies became the first ones, reacted to the changing situation, for example, Alibaba, which created a successful digitalized corporation's model and financial service AliPay, as well as Tencent with its WeChat Pay. These alternatives creation to classical banking led to a decrease in its popularity; a specific assessment is given by S&P (Wang 2019). But it can be noticed that fluctuations in the issue of bank cards emission were at 5–7% in the first months after each service release. Thus, Chinese banks needed to catch up with companies in the real sector in the digital services provision. All foregoing was the result of liberal reforms in the banking sector and the Western banks' penetration into the Chinese market.

Nevertheless, Western banks are not ready to actively participate in China's economic development; and the Chinese economy's priority sectors in the viewpoint of development goals are of little interest to them. Besides Western banks' functioning model is not adapted to Chinese realities. That's why, today, most of the digitalization and its attendant changes are realized by Chinese banks themselves, and at the same time quite efficiently (Fig. 2).

Thus, digitalization from the inside and outside is quite harmoniously combined in the Chinese economy and it is realized mainly through the several Chinese corporations' finances—Alibaba, Tencent, Xiaomi (Xiaomi Finance), Yillion (Shiao 2020). These companies try to occupy foreign markets.

Chinese banks, despite the planned economy where they exist, turned out to be highly adapted to modern realities, moreover, the risks inherent in their activities were moderate (Wang 2019), at the level of developed countries' banks. It is necessary to notice that the technological revolution takes place

Fig. 2 The foreign banks' position in the Chinese market (Compiled by the authors), billion renminbi (Gilder et al. 2019)

in China's economy (Gilder et al. 2019), that's why the PRC economy's digitalization is very high. It is necessary to notice that the level of economy's digitalization correlates with the level of banks' adaptability in the case of the PRC, so the authors suppose that digitalization is not a process, but it is a kind of public institution, characterized by blurred outlines, but specific manifestations.

In addition to that, Chinese fintech contributes to the development of the green sector. The Chinese economy functions in the framework of centralization, but SMEs play a significant role in it. In addition to that, the ecological situation in the big cities of the country is rather bad. All in all, Chinese fintech contributes to the development of the green finance and green technologies through several measures, for instance, issuing the green bonds. The other side is that the Chinese banks are big institutions, which have significant amounts of financial resources, which they can invest in the promising green projects. The current situation in that sphere in the world is quite messy—the green fintech almost isn't regulated, so the Chinese authorities in the plan economy have to do it manually. The People's Bank of China has adapted to the current conditions and put forward a pilot project of green finance monitoring in the 36 banks, hence being able through the AI, cloud computing and other technologies to monitor the green deals (Paulson Institute Green Finance Center and Research Center for Green Finance Development at Tsinghua University 2020). Huzhou bank has developed an automatic system of assessing how green in the project, which asks for green financing, while the People's Insurance Company of China has developed a system of remote risk and losses assessment, based on the new technologies (Green Finance Center and Paulson Institute 2020).

The other example of the green fintech in China is Huzhou, where One-Stop Service Platform has been launched for SMEs, contributing to the 60% of the Chinese GDP. This platform offers access to the green projects, launched by the SMEs to the banks and institutional investors, while the SMEs can track the interest of other parties to their projects. Alibaba has also joined the trend, but for now only declaratively, joining with the UNEP in forming a more sustainable business model.

All in all, China goes by the way of greening fintech, but today all the projects, despite being numerous are separated from each other and aren't interconnected, moreover, some of them are experiments, which still have to start functioning in their full strength (Bal et al. 2014).

2.2 Shadow Banking and Digitalization in China

The shadow banking volume in China is still difficult to determine accurately, probably, it occupies from 50 to 65% of GDP in the PRC economy (Sun 2019). This is a very large share of the shadow sector, which is practically not regulated by the state; this fact creates significant problems in the realization of the state monetary policy.

Digitalization is making adjustments to the shadow sphere: if earlier it was a question of creating a loan from assets which were not controlled by state supervisory authorities, now the demand for shadow credit has also increased because of speed increase of the money circulation. At the same time, digitalization allows state control authorities to clearly specify financial flows and organize control over the funds' movement. This measure has made the shadow banks' existence much more difficult (Gruin and Knaack 2020). In the whole, digitalization has more positive than negative effects here: the shadow banking growth in China has slowed down (Ehlers et al. 2018), but still, its share remains high, especially in lending households and socially significant projects.

The authors suppose that the digitalization effects have not yet fully manifested themselves, as the Chinese economy is characterized by a lag between the industry regulation strengthening and the search for new ways to avoid it. With high probability, shadow banks will soon turn to new loan generation sources, for example, to cryptocurrency, or to Western partners who will be ready to act as trust funds. In fact, there are much more schemes for using digital technologies in the financial sphere than the possibilities for their regulation by financial monitoring bodies. At the same time, we should expect an increase in the shadow banks' share in the PRC economy in the future, as the shadow sector plays the stimulator role for a number of PRC economy's sectors; consequently, in the conditions of a PRC economy's slowdown, the shadow sector regulation will be relaxed with a high probability.

3 Results and Discussion

As the current trends' analysis of the Chinese banking system development shows, the Chinese banking system is highly adaptable but it has insufficient control level. This leads to the fact that the Chinese shadow sector of the banking system is the largest in the world. It is also necessary to understand that current banking system development trends are determined by the digitalization and financial technologies development. As it was said, digitalization and fintech give not only negative but also positive changes in the situation. The authors propose ta take a set of measures to reduce the shadow banking impact on the Chinese economy while maintaining the positive effects that it gave China in terms of economic development.

(1) It is necessary to create a system for monitoring financial transactions in the country in the Internet sphere and oblige banks to generate reports on suspicious transactions. As a number of large banks in China have subsidiary banks operating in the shadow sector (Shiao 2020; Tsai 2015), the same task must be entrusted to the PRC financial control service, but for transactions which were not declared suspicious. Due to the extremely high volume of data, it is required to develop an automated transaction control system based on Big Data algorithms.
(2) It is necessary to integrate the financial Chinese trading companies' innovations in China's financial sector. It is necessary to combine financial and trading services under one umbrella brand: Alibaba has managed to realize it, but, for example, Tencent is not a tangible goods seller, that's why, it is logical, for example, to form a WeChat Pay block—Xiaomi Finance or to create new electronic platform commerce such as Aliexpress. In general, this measure is aimed at definancialization the economy and the payment sector to be out of the shadows; such giants as the listed companies will carry out financial monitoring on their own.
(3) It is necessary to create a consumer lending system, microloans, and social lending systems in a transparent economy's sector, without a shadow loan use. To do this, the services of the same companies which were proposed above can be used; for example, to create an investment platform for small enterprises on the basis of Aliexpress, or a social lending fund on the basis of companies' financial mechanisms. If the company creates this social lending fund, the state can ease its tax burden; in this case, this measure may attract big companies such as Huawei and Xiaomi which are two largest digitalization drivers in China and owners of their own financial innovations.
(4) It is necessary to develop legislation in the field of foreign banking enterprises in China. This will allow using foreign banks' borrowed financial resources, but at the same time, there won't be an increase of foreign agents' influence on the Chinese economy.
(5) It's necessary to build a united and systematic approach to the green fintech in China in order to develop a really green financial system, to avoid the false-greening. This system is to be built on the basis of the PBOC, other state banks and big corporations with state participation.

The proposed recommendations are measures which will allow the PRC economy to reduce transaction costs and to be more competitive in the digitalized world. At the same time, the real sector development lies in the Chinese economy's heart. This fact differs China's economy from the developed countries' economies where digitalization was based on the economy of services. That's why the digitalization models of the Chinese economy should also be based on the cost reduction of the real sector companies. These measures will allow to reduce the negative finance effects, which has recently been observed in Asia and China in particular (Wang 2017).

4 Conclusion

The research showed that digitalization and fintech are concepts, although similar, but differing in essence: if fintech are new tools, being used to make more profit in the financial market, then digitalization is a process which is characterized by the widespread new technologies use.

The second significant result was proof that the Chinese banking system is not so closed as it seems during its initial consideration: its digitalization goes both inside and out. At the same time, these two processes harmoniously complement each other but can cause serious changes in the country's economy if the shadow sector which they stimulate is not taken under control.

The Chinese economy's shadow sector is the biggest problem of China's financial system. This problem's solution lies in creating alternatives to the shadow sector's tools through the real sector companies' tools. Digital technologies should become an important element in the fight against the shadow banking sector. They will make it possible to bring this sector's operations into a transparent economy. To avoid the inefficient public resources use, it is possible to use the non-financial sector companies' tools which they use in order these technologies to penetrate into consumer and social lending, which are most heavily connected with the shadow sector.

The Chinese economy conducts an interesting experiment in the sphere of green financial innovations and fintech. It's notable, that the majority of these projects come from the Chinese government, which pursues the goal of planned greening of the economy, so has to develop an effective control system of the green initiatives or the united platform of the green financial technologies.

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Transition of Business Information to Electronic Exchange: Foreign and Russian Experience

Victor A. Onuchak and Maria A. Khalturina

1 Introduction

The history of world data standardization began in 1928 at the International Conference Relating to Economic Statistics, organized by the League of Nations. After World War II, the history of creating international standards continued with the release of the UN-sponsored Measurement of National Income and the Construction of Social Accounts in 1947, and the Balance of Payments Compilation Guide (Balance of Payments Manual) from the World Bank in 1948.

With the advent of computers in 1953, the most difficult task in the field of standardization arose: the transfer of information to electronic media. This process began with the creation of internal standards for coding statistical data, and at the end of the twentieth century, with the development of electronic means of communication and the development of standards for electronic exchange of information.

In the late 90s, with the onset of a new stage of globalization of the world economy, there was a clear need to speed up and simplify the process of collecting and sharing financial information. At the earliest stages of electronic exchange, there were EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport) formats—electronic data exchange

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for administrative bodies, commercial and transport enterprises, a standard for syntax rules for exchanging data in these areas, PDF (Portable Document Format) and Microsoft Excel, which did not allow automation of data consolidation and analytics.

In 1993, the United States obliged public companies to submit reports in electronic format, and then the EDGAR (Electronic Data Gathering, Analysis and Retrieval System) system was introduced, which allowed users to find all the information about the issuer of interest to them on the website of the US Securities and Exchange Commission (SEC) as PDF files.

Until now, for many enterprises around the world, the publication of reports in electronic format is limited to its publication in PDF, Excel and PowerPoint formats on their official websites. Final accounts are published with significant delays, for example, audited annual accounts of Lukoil are published at the end of the first quarter of next year. In addition to the fact that obtaining financial information with such a significant time lag complicates and makes the analysis of the company's activities irrelevant, translating information from PDF and PowerPoint to Excel is a very time-consuming task, given the fact that the annual reports of some companies can be up to hundreds of pages (taking into account the auditor's reports and notes to the accounts).

The digitalization of the economy made it possible to find a solution to the problem of simplifying and accelerating the transfer of financial information. Over the past 20 years, there have been profound changes in the field of digital technologies and artificial intelligence. Network and cloud spaces have been created, and significant progress has been made in machine learning. Computer processing of "big data" (bigdata) and the development of the Internet have enabled companies to exchange business information faster and more efficiently.

2 Methodology

In the process of studying the problem of the transition to standardization of business information in the field of sustainable development and its transformation into electronic media, the author used methods of comparative and statistical analysis.

3 Results

The study showed that the transition to digital exchange of information allows not only to standardize and unify the reporting format, but also to increase the speed of data transfer, reduce company costs, and increase the trust of supervisory authorities and investors in the company.

In the early 2000s, Charles Hoffman, an accountant from Washington state (USA), with the participation of the American Institute of Certified

Public Accountants, developed an open standard for the exchange of business information XBRL (eXtensible Business Reporting Language), the main goal of which was to improve the process of providing business information and increase the transparency of business around the world by regulating the exchange of financial information.

XBRL literally translates to "extensible business reporting language"—it is a global open standard for the exchange of business information that allows you to express common business reporting requirements for market participants and regulators using semantic means (programming).

This standard is one of the main means of communication and information exchange between business systems, which are based on the sets of reference books and data characteristics (metadata) described in taxonomies, containing a description of both individual reporting indicators and the relationships between them. The report containing this information intended for exchange is the XBRL report.

The core of the XBRL system is the XML language base. This system includes the following concepts:

- data templates (filled in by market participants);
- metadata (a set of reference characteristics);
- data models (describe objects and data structures and their relationship with metadata);
- reporting forms (based on metadata and data models);
- taxonomy (a set of the above concepts).

Thus, this XBRL system allows you to generate financial statements using ready-made templates and exchange information through a set of metadata, which, in turn, contain descriptive characteristics of individual reporting indicators and their relationship.

XBRL is the international technical business language spoken by regulators and market participants in the context of financial information. It is developed by the international non-profit organization XBRL International. It includes more than 600 public and private sector participants. Users of this standard can include central banks, financial market regulators, banking regulators, tax authorities, national statistical agencies, and private enterprises in over 60 countries. Russia joined XBRL International as a special member on June 10, 2015. The G20, EU and BRICS countries are also gradually implementing the XBRL standard. Among the countries that have already successfully implemented it are the USA, Great Britain, Germany, France, Italy, The Netherlands, Sweden, Finland, China and India.

The original users of the standard were regulatory bodies, namely the US Federal Deposit Insurance Corporation and the Committee of European Banking Supervisors (CEBS). It is worth noting that the US and EU are by far the most advanced XBRL users. Since 2009, the US Securities and Exchange

Commission has mandated the use of the XBRL standard for companies listed on the US securities market. The United States is actively developing and implementing changes to the standard. In 2018, the Commission's website published a message about the transition to the new iXBRL (Inline XBRL) standard, which should further simplify and accelerate the exchange of business information. The advantage of this format is the ability to render reports in a regular browser without losing any part of the report functionality. Such a report becomes readable for both a machine and a person.

In Europe, the European Central Bank, being a mega-regulator, is actively introducing the XBRL standard, since 2005, to unify reporting and collect information from supervised authorities and various European institutions. The European Securities Market Supervision Authority (ESMA) in May 2019 obliged all companies listed on the European securities market from January 1, 2020 to submit reports in a single electronic reporting format (The European Single Electronic Format [ESEF]) using taxonomy iXBRL.

The UK experience with the transition to XBRL began in 2010, when Her Majesty's Revenue and Customs Authority (HMRC) required supervised entities to provide tax information in XBRL format. Companies could also submit XBRL reports to UK Companies House (CH). On April 1, 2015, the UK, like the US, began using the iXBRL format.

However, not all countries are willing to migrate to the XBRL taxonomy, so they are developing their own. For example, China developed its CAS (China Accounting Standard) taxonomy in 2010, which in turn received approval from XBRL International. China evolves annually in digital reporting and publishes information on how the use of XBRL helps monitoring and information management processes. not only to regulators, but also to business. China's transition to the XBRL format allowed domestic companies to become more active participants in international markets, as it gave Western investors a much better understanding of the market.

Russia, in turn, is also actively involved in the process of unification and standardization of financial reporting. In 2014, the Bank of Russia conducted a pre-project study of all formats that evolved from the XML format and chose XBRL as the most functional, secure and convenient one. According to the roadmap of the Central Bank of the Russian Federation, since 2018, the use of the XBRL standard is mandatory for:

- insurance organizations and mutual insurance societies;
- non-state pension funds;
- professional participants in the securities market, trade organizers, clearing organizations and persons performing the functions of a central counterparty;
- joint stock investment funds, management companies of investment funds, mutual investment funds and non-state pension funds.

The transition for credit rating agencies and insurance brokers was planned for 2020. The next in line are specialized depositories (SD) and microfinance organizations, their transition will take place in 2021. The remaining non-bank financial institutions are expected to migrate to XBRL from 2022.

The transition to the publication of reports in a new format requires addressing the following issues:

- Reorganization of all the processes in the company;
- Retraining and training of employees;
- Conversion of different formats for collecting information into one;
- Creation and updating of the corporate data model and reports;
- Bringing methodological and technical documentation to a single format;
- Centralization of IT systems and their integration into each other at the data and interface level;
- Consolidation of data from different segments (methodological and technological).

The world experience of using the XBRL standard shows that, despite certain costs for its implementation, the new standard has many benefits and advantages that are not limited only to accelerating data transfer or unification and standardization of the reporting format.

First, the use of the standard significantly reduces the cost of reporting. Today, due to the complication of reporting, the time for collecting and finalizing reports in different companies can range from one week to a month, and earlier if only one employee could deal with the preparation and control of reports, now this requires a whole department, the size of which can exceed 10–15 people. The use of XBRL, increases the speed of information updating and simplifies the data transfer process and makes the reporting process the least time consuming. According to XBRL research, today, standardization and digitalization of reporting, the use of special software, can reduce labor costs by up to 90%. Moreover, the transparency, accuracy and reliability of the information provided increases, which ultimately increases the confidence of regulators and investors in the published reports.

Secondly, paperwork is eliminated, which makes it possible to significantly reduce the size of archives from a separate office space to a digital medium, the size of which in most cases does not exceed a notebook sheet. It should be noted that the transfer of paper archives to digital media also helps to reduce the company's costs, since there is no need to rent additional space for archival premises.

Third, due to the fact that the XBRL standard does not consolidate reports, but only data, the information, loaded into the system once, can later be downloaded, presented and analyzed in a different format. Thus, redundancy and duplication of data for the publication of different types of reporting is eliminated. This reduces the burden on both government regulators and accountable organizations.

Moreover, the high interactivity of the data increases the capabilities of analytics, allowing users to quickly extract exactly the information they needs in any context and for any period of time. The unification and standardization of reporting allows users not to waste time on decoding and putting it into the desired form and gives the user the opportunity to immediately proceed to the analysis and comparison of indicators with previous years or even with other companies in the industry.

In addition to the benefits that XBRL brings to regulators and investors, the application of the standard also brings benefits for internal use. In a large company, a multi-level holding company, or an enterprise with a complex structure, the standard can improve the efficiency and quality of the exchange of financial information between departments, financial services, and the treasury. In addition, the application of the standard takes internal control to a new level, simplifies and accelerates inspections, and makes it possible to track financial transactions online, regardless of the geographical network of the supervised entity's presence.

In modern conditions, the governments of most countries and their supervisory organizations sharply raise the issue of not only the financial condition of enterprises, but also their sustainable development, in particular, this applies to enterprises in the energy industry.

In June 2019, the US Federal Energy Regulatory Commission issued an XBRL mandate requiring energy companies to publish reports in XBRL format.

According to the Directive of the Chairman of the Government of the Russian Federation of March 30, 2012 No. 1710p, state-owned companies and some companies with state participation are obliged to publish non-financial reports, namely, reports on sustainable development. Despite the fact that the purpose of such reporting is to increase the information openness and transparency of companies' activities in the field of social responsibility, the task of tracking and understanding the real activities of the company in this direction remains difficult.

According to the author, this problem can be solved by developing a guide to harmonize accounting principles and metrics that organizations can use in their reports on economic, environmental and social activities, and subsequently publish such data using the XBRL taxonomy.

Such a system of indicators will not only allow monitoring of current indicators, but will also make it possible to identify a trend for a certain period and most fully disclose information about the environmental pressures, protective measures taken by companies, and to determine the direction of environmental protection activities.

Indicators can be defined as qualitative and quantitative. Qualitative metrics play a preventive role, "warning" the company about possible deviations in quantitative metrics. An example is the frequency of oil pipeline inspection. As an example of quantitative indicators, one can cite the indicator for emissions of pollution into the air or water bodies.

When developing indicators, it is necessary to take into account such criteria as:

- *Relevance*: The indicators should provide tangible information, that is, information that can influence the decision-making of the user of the reports. Moreover, the information should be as updated and as accurate as possible.
- *Comparability*: The indicators should be comparable with each other in different periods of time, and also comparable to those of other similar mines.
- *Clarity*: Metrics should clearly show users what they are measuring, and language and terminology should also be clear to users.

  When developing a scorecard, it is very important to identify indicators that can help in the fight against environmental threats.

  An example is the indicators from Table 1.

Table 1 Indicators that can help in the fight against environmental threats

Threat	*Effect*	*Indicator*
Climate change (global warming)	• The nature and total amount of greenhouse gas emissions into the atmosphere; • Volumes of deforestation;	• Volumes of CO_2 emissions; • The number of energy-saving devices and the percentage of expenses from total expenses and from income, for the acquisition of these OS; • The area of forests planted by the organization or by its order; • Percentage of clean energy produced in a sustainable manner (own or purchased) compared to total energy consumption.
Environmental pollution	• Environmental pollution due to the activities of the organization (waste disposal in water bodies, emission of pollutants into the atmosphere)	• Types and volume of emissions into the atmosphere; • Total weight of waste discharged into water bodies.
Consumption of natural resources	• Industrial use of water from nearby water bodies	• Volume of consumed water

External control is directly related to internal control. A kind of integration of these types of controls is that the external user of information receives the same data that internal users have, but in a more generalized form. For example, if a user wants to view information on fixed assets (fixed assets), then in the balance line he will see the total cost of fixed assets and separately accrued depreciation. In some cases, assets may be categorized, but the reporting will not list each individual asset.

On the one hand, such a generalization is quite acceptable, but on the other hand, such figures may contain significant information. For example, detailed information about what kind of investments and in what area the energy company is trying to improve the environmental situation of its production, how often the fixed assets are updated, whether they carry out preventive maintenance of fixed assets, and so on. This information will be useful not only for investors, but also for regulatory authorities, since a high percentage of depreciation of fixed assets or the lack of preventive maintenance can cause an environmental disaster.

Within the framework of the Main Directions for the Development of Financial Technologies for the period 2018–2020 adopted in 2017, it is planned to develop and implement measures for the implementation of RegTech (Regulatory Technology) and SupTech (Supervisory Technology) technologies in the Russian market.

According to the document, RegTech technology will simplify the implementation of the regulator's requirements by financial institutions and can be aimed at assessing the internal control system, customer identification processes, information protection, risk management, transaction monitoring, and environmental reporting.

This should also help automate and simplify administrative procedures, digitize information collection and decision-making processes, increase the reliability and quality of data, and improve the efficiency of decision-making by the regulator.

The positive effects of the implementation of digital solutions in the XBRL format should be attributed to the speed of detection of suspicious transactions and fraudulent schemes as an evidence base in the investigation of financial and environmental crimes.

First of all, among the innovations, it should be emphasized that the introduction of the XBRL format represents the transfer of requirements for all categories of organizations to a unified form of international business reporting.

4 Conclusion

Based on the results of the study, it was concluded that the use of the XBRL standard in order to control the sustainable development of enterprises will more effectively solve environmental problems. When developing the main indicators, criteria such as relevance, comparability and clarity should be taken into account.

Thus, the authors believe that information related to the environmental side of the issue should be published in as much detail as possible and should be available to all interested parties.

A similar initiative was raised in early 2020 by the Vice President of the European Commission in his speech at a conference on IFRS. The European Commission is already reviewing its non-financial reporting directives and is calling on the International Accounting Standards Board to begin work on an iXBRL-based non-financial reporting standard. The standard should be easy to use, and the information should be comparable across countries to enable timely detection and prevention of global environmental risks.

The IFRS Taxonomy XBRL is a complete mapping of IFRSs in XBRL format used to communicate information between organizations. Online financial reporting data can be of great help not only to statisticians, analysts, investors, reporting users, but also to the financial manager of the reporting company.

The main uses of the XBRL standard include:

- collection and verification of data from supervised organizations by official regulators;
- internal exchange of information by government departments and agencies;
- internal data exchange by the commercial sector.

Apart from this, a new direction for the exchange of non-financial information could be added in order to increase the transparency of activities in environmental matters.

This is especially important for increasing the representativeness of statistical information in this area, improving forecasts for improving the environmental situation, creating world databases of statistics that satisfy the needs of various categories of users, both domestic and foreign.

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How Does Green Robotics Differ from Conventional Robotics: Comparative Analysis

Oleg B. Pichkov, Alexander A. Ulanov, and Olga S. Vinokurova

1 Introduction

At the moment, humanity is experiencing the Fourth Industrial Revolution, characterized by the widespread use of data and the introduction of digital technologies, to which robotics can also be referred according to K. Schwab, one of the prominent theorists of Industry 4.0, the founder and the President of the World Economic Forum in Davos (Schwab 2017).

It should be noted that "robot" has many definitions that emphasize various aspects of this multi-faceted, interdisciplinary phenomenon, depending on the context of application. For the purpose of this research, it is proposed to use the definition given in the ISO 8373:2012 standard "Robots and robotic devices. Terms and definitions", according to which the robot is "actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks" (ISO 2012).

The above mentioned characteristics are of great importance in the context of environmental friendliness of robotics. In particular, the nature of the robot

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as a programmable mechanism implies the presence of various, including electronic, components that need to be disposed of or recycled after the end of their useful life. The ability to move the device in turn raises the issues of energy consumption and the related environmental aspects. The tasks assigned to a robot can also be evaluated in terms of their possible consequences for the environment.

An important modern feature is the coexistence of widespread digitalization trend amid the society's request to reduce the anthropogenic and technogenic load on the environment and the increased emphasis on the environmental agenda.

This trend has not spared the field of robotics. Green robotics is increasingly a research subject. It seems that the proper approach to the definition was proposed by I. Gonzalez: "green robotics refers to environmentally sustainable robotics. The goals of green robotics are similar to green chemistry; reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote the recyclability or biodegradability of defunct products and factory waste" (González et al. 2014).

The global energy sector is responsible for the steady increase in greenhouse gas emissions, in particular carbon dioxide (CO_2), which is among the key issues on the current global environmental agenda. Thus, as of 2019, the annual volume of carbon dioxide emissions from the industry was estimated at 33 billion tons (IEA 2020a). Even the COVID-19, the coronavirus pandemic in 2020, which was accompanied by a lar2ge-scale decline in the economy and energy consumption, according to the International Energy Agency, contributed to the reduction of the corresponding indicator only to the level of 30.6 billion tons of CO_2 (IEA 2020b), which in absolute terms, however, is a significant amount. With the exponential growth in the number of robotics devices, robots can become globally significant energy consumers in the future. Given the high level of energy intensity of modern robotic systems, the problem of energy is among the central ones for the industry.

It should be noted that heavy unmanned aerial vehicles (UAVs) and unmanned ground vehicles need fuel—primarily fossil fuels. Lighter robots and drones operate on the basis of electricity, which is often used by designers to promote devices as "environmentally friendly". However the power industry accounts for a significant amount of carbon dioxide emissions. Thus, the issue of improving the energy efficiency of technology, including robotics, is becoming one of the key issues in global sustainable development at the present stage.

It is important to note that digitalization is often associated with expectations for environmental improvement. For example, less paper consumption and therefore less harm to the environment are often mentioned as the advantages of electronic document management systems. At the same time, it should be noted that the widespread use of information technologies and related devices taking into account accelerating life cycle of high-tech products leads to excessive volume of electronic waste, which might pose even more threats to nature. Humanity produced 53.6 million tons of this type of waste in 2019 alone, according to the International Telecommunication Union. By 2030, this figure will reach 74.7 million tons, according to a forecast (Forti et al. 2020). The growth in the use of robotics containing many electronic components seems likely to contribute to the above-mentioned e-waste increase.

Both the accumulated damage to the environment and a growing number of man-made disasters call for the involvement to use the most modern technologies to eliminate environmental damage. Green robotics can be a solution.

2 Methodology

This study is based on the methodology of comparative analysis of conventional and green robotics.

The comparison criteria are identified, based on the results of studying an array of scientific publications on the environmental aspects of the development and use of robots. A review of the available research has shown that such aspects include the level of energy consumption and energy sources of devices, materials for manufacturing robotic systems and their components within the context of subsequent recycling, issues of integrating robots into existing ecosystems, as well as their intended purpose to solve environmental problems.

Examples of robotic developments are provided for each of the relevant criteria to illustrate the thesis.

3 Results

The results of the study are presented in Table 1. Analysis of specialized publications shows that the classification of robotics as green is often made on the basis of compliance with at least one of the following criteria.

4 Energy Consumption

Modern robotics devices get their energy primarily from electricity or from fossil fuels. At the same time, as UN experts point out, "fossil fuels comprise 80 per cent of current global primary energy demand, and the energy system is the source of approximately two thirds of global CO_2 emissions" (Foster and Elzinga 2020).

As noted by M. V. Koval'chuk and O. S. Naraikin, "science today provides the opportunity to create fundamentally new generation and energy consumption technologies modelled on nature—so called nature-like technologies. The purpose of creating a nature-like technosphere is to restore the natural self-consistent resource turnover that has been disrupted by today's technologies opposing to natural context" (Kovalchuk and Naraikin 2016).

Table 1 Comparative analysis of environmental friendliness of robotics

Criterion	*Conventional robotics*	*Green robotics*
Energy consumption	Receives energy from fossil fuels or from electricity, which in turn also uses fossil fuels. Power consumption is not optimized or not enough optimized	Uses renewable energy sources Energy consumption is optimized
Manufacturing materials	Made of standard materials: metals and alloys, plastics, rubbers, composite materials, etc	Made of biodegradable and biocompatible materials
Integration into the ecosystem	Is not adapted to ensure minimal interference with the natural environment	Thanks to applying the principles of biomimetics to the development process, it is harmoniously integrated into the target ecosystem
Intended purpose	Is intended for solving applied problems. Environmental impact is not often a critical factor	Is aimed at solving problems in the field of ecology, including monitoring the state of the biosphere, eliminating the consequences of emergency situations, etc. Indirectly contributes to the reduction of anthropogenic impact on the environment through providing for remote interaction

Source compiled by the authors

In terms of robotics, a number of solutions is possible, both to reduce energy consumption and to obtain energy from alternative sources.

At the present optimization of robot energy consumption is carried out only to the extent required by the solution of applied problems. However, improving the energy efficiency of robotics is possible at the algorithmic level by changing the sequence of operations performed, optimizing the route of device movement, or simplifying the process of computing and data exchange (Alves Filho et al. 2018). Experts consider the corresponding technological solutions to be among the green robotics approaches.

The demand for improving the energy efficiency of robots was reflected in a joint appeal from the European Association for the Co-ordination of Consumer Representation in Standardization (ANEC) and the European Consumer Organization (BEUC) to the European Commission with a recommendation to extend the requirements of ecodesign and energy labelling on the popular devices of personal service robotics—robot vacuum cleaners (Maigret 2019).

The transition from finite resources to renewable energy would also serve as a significant step to improve the environmental friendliness of robotics.

Experts from the University of Alexandria point out that renewable energy sources "are most appropriate for powering mobile robots. Moreover, the type of mobile robot dictates the appropriate renewable energy source to be used to power the robot. Solar energy is an appealing option for all robot types. The high efficiency of hydrogen fuel cells makes them attractive for flying robots, while wave energy is an obvious option for marine robots" (Hassan et al. 2019). The experience of scientists at the Bristol robotics laboratory should be noted: they developed the Ecobot III device with an artificial digestion system based on microbial fuel cells. Laboratory samples of wastewater and its sediment were used as energy carriers. The robot's design involves converting the energy of chemical bonds of organic substances into electricity through microorganisms to ensure the movement of the device and further collection of resources from the environment. The researchers note that "this integration between biology and machines has been described as (artificially) symbiotic and has resulted in the introduction of a new class of robots known as Symbots" (Ieropoulos et al. 2010).

5 Manufacturing Materials

Manufacturing materials are of great importance for the environmental friendliness of robotics. As noted earlier, the growth of electronic waste pollution is one of the most significant problems today as devices and their components contain toxic substances. Increasing interest in the use of robotics in various fields may complicate the situation. Metals and alloys, plastics, rubbers, composite materials and other materials are used to manufacture robots. However, some of them may pose a particular danger to the environment. For example, dioxins are formed from the burning of one of the most common types of plastics—polyvinyl chloride (PVC), which are known to be carcinogenic.

Thus the use of biodegradable materials that are safe for nature is becoming increasingly popular.

For example, a prototype of an unmanned aerial vehicle developed by a team of specialists from Stanford University, Brown University and Spelman College attracted a great interest from the professional community at the International Genetically Engineered Machine (iGEM) 2014, the international competition of projects in the field of bioengineering. The body of the device was made of mycelium of fungi in a shell of cellulose produced by bacteria. The complete biodegradability of these materials was stated to be their advantage (Shumate et al. 2014). Therefore, if the drone is lost, it is assumed that the damage to the environment will be negligible.

The creation by the Johannes Kepler University Linz team of an executive device in the form of an elephant trunk using a biogel based on gelatin, glycerol and citric acid is another example. And again the designers emphasize the complete biodegradability of the resulting material and its prospects for use in soft robotics (Baumgartner et al. 2020). This direction of robotics is based on the use of soft materials similar to the living tissues.

At the same time, it should be noted that the onboard electronics of robots and the avionics of drones are still made from traditional materials. It should be emphasized that the work on creating environmentally friendly electronics is not easy and might be challenging, but it is an important direction for the development of modern technologies.

6 Integration into the Ecosystem

Robotics and unmanned aerial vehicles can be in demand for solving environmental monitoring tasks largely due to their ability to perform their functions with minimal interference in the environment. The devices used in this field are called eco-drones and are often based on the principles of biomimetics—imitation of biological processes, forms and structures.

An autonomous robotic fish is one of the most well-known projects in this field, designed by experts from the University of Essex on the basis of studying the nature of fish movement and applying the principles of bionics. The research resulted in the design of a prototype that can move like a fish and perform autonomous navigation in three-dimensional space in dynamically changing conditions (Hu 2006).

Unmanned aerial vehicles are used to track the movement of endangered swift parrots across Australia. The team of researchers notes that drone surveillance helps to reduce the anxiety of the studied objects: "Whereas birds would often move between adjacent trees when humans approached, they would often continue with observed behaviors when the robot was flying nearby" (Cliff et al. 2018).

However, it should be noted that using large and noisy professional and personal drones, especially at low altitudes, was previously assessed as a new factor of negative impact on the environment (Mulero-Pázmány et al. 2017).

The appearance of a robotic device can matter a lot too. In particular, there are good opportunities for zoomorphic and insectomorphic systems.

Therefore, it can be stated that one of the significant criteria for the environmental friendliness of a robot or unmanned aerial vehicle can be the degree of its impact on the target ecosystem when performing the tasks. Minimal interference with natural processes during integration allows the corresponding device to be classified as green robotics.

7 Intended Purpose

The intended purpose of robots is also important for ecology. At the present, robotics is divided into two major groups: industrial and service. The latter is divided into professional and personal subgroups. According to the definitions contained in ISO 8373:2012, industrial robots are "automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications" (ISO 2012). Service robotics includes devices "that perform useful tasks for humans or equipment excluding industrial automation applications" (ISO 2012). Medical robots or robotics for emergency response are the examples of service robotics for professional use. Window cleaning robots may be referred to as personal service robotics devices.

It is obvious that protecting the environment is not the key task of most robots. Moreover, the indirect effect of their use on the environment is not so clear. The use of industrial robots, taking into account an increasing reduction in cost and an increase in the rate of production, can potentially contribute to overproduction and complicate the problem of subsequent disposal of consumer waste.

At the same time, there are increasingly more projects in professional service robotics aimed directly at solving existing environmental problems. For example, a new impetus to development of oil-collecting robots was given after the oil spill in the Gulf of Mexico in April 2010. "A swarm of sea robots can be used in collecting an oil spill in the sea more successfully and efficiently than most of the other methods", according to experts (Zahugi et al. 2013). Moreover, in the case of small spills, the use of robots can help to reduce the cost and shorten the duration of recovery. Seaswarm—the prototype of swarm of oil recovery robots, designed by a team of researchers from the Massachusetts Institute of Technology is one of the most well-known recent designs in this area (Ratti et al. 2010).

Robots are very popular for monitoring the state of the biosphere. In particular, unmanned vehicles have proven their effectiveness in assessing the dynamics of temperatures and oxygen concentrations in reservoirs, as well as conducting physical and chemical measurements in lake ecosystems (Grémillet et al. 2012).

It should be noted that the use of robotics can also have an indirect positive impact on the the environment. As pointed out by robotics experts at Plymouth University and Carnegie Mellon University, "robots could save transport costs through flexible tele-presence, e.g. in health care" (Bugmann et al. 2011). A reduction in a number of business trips may lead to a reduced impact of transport on the environment.

8 Conclusions

Designers of robotics devices need to strike a balance between various characteristics of robots, including their performance, energy consumption, ergonomics, cost, etc. That is to say, they are forced to solve multi-criteria optimization problems (Alves Filho et al. 2018), bearing in mind priority areas when developing specific devices and sacrificing less significant ones. Given the specifics of the robotics industry, environmental characteristics are not often among the key ones.

However, according to the authors, the importance of the environmental factor of robotics will only grow taking into account the increasingly popular circular economy concept and the introduction of nature-like technologies.

Therefore, further research requires interdisciplinary interaction of practitioners-designers of robotics and environmental specialists, to expand and to precise the proposed list of criteria for referring robots to green robotics. At the moment the criteria are as follows: the level of energy consumption, the environmental friendliness of manufacturing materials, the degree of integration into the ecosystem, and the purpose of the device in the context of its impact on the environment.

Taking into account a sporadic character of scientific publications on the environmental impact of robotics, it seems that the continuation of this research would make a significant contribution to the emerging theoretical base on this issue.

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Managing Industry 4 Technology and Innovation

Jeff Schubert

1 Introduction

Each of the so-called "industrial revolutions" has brought significant changes in the ideas and practice of what we call "management". This paper aims to explore management changes that might be needed or occur when attempting to use Industry 4 technologies—including to mitigate climate change!

Much is now being written about how COVID19 might change the "future of work" (Hill 2020) and management. Rightly or wrongly, I do not attempt to venture any views on this issue.

There is no precise definition of the Fourth Industrial Revolution, or Industry 4. Most definitions include artificial intelligence (AI), big-data analytics, advanced human–machine interfaces, robotics, the Internet of Things, autonomous vehicles, 3D printing, biotechnology, smart sensors, augmented reality etc.

Books and texts directly addressing the issue of management in the context of Industry 4 are not common, and those that are available can be very disappointing. For example, the World Economic Forum released a so-called White Paper (World Economic Forum 2019) in December 2019 considering the role of Human Resources professionals and departments in dealing with management issues. Despite being produced in collaboration with a number

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of significant international companies, the document is full of platitudes and generalities and has very little that is new.

A much earlier 2016 paper, "Management Approaches for Industry 4.0: A Human Resources Management Perspective" (Shamim et al. 2016) is more useful. The authors say that their paper is an initial attempt "to draw the attention towards the important role of management practices in Industry 4.0" and that "most of the recent studies are discussing the technological aspect".

A 2019 paper, "Lessons learned from Industry 4.0 implementation in the German manufacturing industry" (Veile et al. 2019) says that "in management research, Industry 4.0, its implementation and its economic, environment and social implications represent a comparably young field" and that "so far, there is little experience in corporate practice with respect to a purposeful and successful Industry 4.0 implementation." They say that "up to now, literature provides corporate practice with general and highly aggregated recommendations that are difficult to grasp and usually disregard company specific characteristics". They say their goal is to correct this.

Veile et al. base their paper on "in-depth expert interviews" with "13 managers from Industry 4.0-experinced German manufacturing companies" during mid-2016. They admit that the focus on German companies and on manufacturing may limit the broader usefulness of their research.

The 2017 book, How Google Works (Schmidt 2017), might be considered to be before Industry 4 and at the tail-end of the 3rd IR. This book is focussed on a particular organization but it also explores some more general management issues that could apply outside the narrow internet based virtual world to the wider Industry 4 world which includes more physical products.

The authors offer a bold statement: "We wrote How Google Works because we believe that the art and science of management has changed in the twenty-first century. Empowered by information and technology, individuals and small teams can have enormous impact, far greater than before."

2 Methodology

This paper mainly looks at the similarities and differences in the views and recommendations of Saqib Shamim et al., Johannes W. Veile et al., and Schmidt et al. In addition, it considers evidence and views of several other relevant sources, such as Amazon, but especially Peter F. Drucker's (1986) book, "Management Tasks, Responsibilities, Practices" (Drucker 1986) has a basis of understanding traditional pre-Industry 4, management ideas. Although there are literally thousands of more recently written books, Drucker's thoughts have rarely been surpassed.

3 Results

3.1 *Industry 4 Management Issues and Suggestions*

Schmidt et al. claim to have discovered a new type of human being! "When we contrast the traditional knowledge worker with the engineers and other talented people who surrounded us at Google over the past decade-plus, we see that our Google peers represent a quite different type of employee. They are not confined to specific tasks. They are not limited in their access to the company's information and computing power. They are not averse to taking risks, nor are they punished or held back in any way when those risky initiatives fail. They are not hemmed in by role definitions or organizational structures; in fact, they are encouraged to exercise their own ideas. They don't quit when they disagree with something. They get bored easily and shift jobs a lot. They are multidimensional, usually combining technical depth with business savvy and creative flair. In other words, they are not knowledge workers, at least not in the traditional sense. They are a new kind of animal, a type we call 'smart creative', and they are the key to achieving success in the Internet Century."

Schmidt et al. claim that since the First Industrial Revolution, management has "been biased toward lowering risk and avoiding mistakes" which results in "environments that stifle smart creatives". In contrast, they claim that now the only way to "deliver great products" is to create an environment where "smart creatives" can "succeed at scale".

They say that "great companies such as IBM, General Electric, General Motors and Johnson & Johnson offer management tracks for people with the greatest potential, whereby these stars rotate in and out of different roles every two years or so. But this approach emphasizes the development of management skills, not technical ones. As a result, most knowledge workers in traditional environments develop deep technical expertise but little breadth, or broad management expertise but no technical depth."

Drucker, who wrote amidst the Third Industrial Revolution, was generally more supportive of "role definitions" and "organizational structures" than Schmidt and Rosenberg. He wrote that "each individual (especially each manager) needs to know where he belongs and what he has to do". However, Drucker also wrote that the "best organizational structure is that which primarily enables people to perform and contribute"—and, as will be noted later, this may change with time and circumstances as "there is no universal design (or even best) principle".

The first principle recommended by Veile et al. for dealing with Industry 4 is rather obvious. They says that employees need to be trained in ICT technologies and an interdisciplinary approach to using them. Individual companies should also cooperate with educational institutions to development and design educational programs tailored to the specific needs of Industry 4.0.

On organizational structure, Saqib et al. say that "Industry 4.0 is characterized by an unstable changing environment, and is compatible with the organic design of organization which is characterized by decentralization, empowerment, few rules and formalities, horizontal communication, and collaborative team work." However, they offer no new ideas. Instead they simply provide descriptions of the well-known organization management approaches of matrix structure, project teams, flat hierarchy and decentralization.

While Schmidt et al. do not use the term "matrix", their sentiments are along these lines. They say that most of today's management processes "were devised over a century ago, at a time when mistakes were expensive and only the top executives had comprehensive information, and their primary objectives were lowering risk and ensuring that decisions are made only by a few executives with lots of information. In this traditional command-and-control structure, data flows up to the executives from all over the organization, and decisions subsequently flow down". They say this approach slows decision making and "means that at the very moment when a business must permanently accelerate, their architecture is working against them".

A 2018 article by Nathaniel Smithson looked at the organizational structure of Google and concluded that it "retains its organization structure" despite becoming only one subsidiary—albeit the biggest one—of Alphabet (Smithson 2018) in 2015. He concluded that it is a "cross-functional organization structure" of the "matrix type", but with an emphasis on "flatness".

Smithson says that "flatness" involves "the minimization of vertical hierarchical lines of communication and authority". In Google this "enables employees, teams, and groups to bypass middle management and communicate directly with upper management" and "facilitates meetings and sharing of information among employees and teams belonging to different areas of the organization". He says that "this structural feature is a major contributor to innovation for novel products that help in business diversification" and bolsters "employee morale, motivation, and satisfaction in their work".

Schmidt et al. often talk about project teams and favour a flat management structure because it fits in with the desires of their "smart creative" types "to get things done" and have "direct access to decision makers". "We call it the rule of seven. We've worked at other companies with a rule of seven, but in all those cases the rule meant that managers were allowed a maximum of seven direct reports. The Google version suggests that managers have a minimum of seven direct reports … With that many direct reports—most managers have a lot more than seven—there simply isn't time to micromanage."

Amazon also emphasises small teams—no more than you can feed with "two pizzas"—of no more than ten or twelve. Werner Vogels, its global chief technology officer says: "If your team is small, everybody on the team knows what everybody else is doing. Once your team starts getting to twenty or twenty five or bigger, you need to start having meetings to understand what everyone else is doing or to define the work" (Swan 2020). And adds: "Basically we are running very small start-ups within the whole bigger Amazon space. We have thousands of these teams, all solving different problems. Amazon is a technology company."

While the best exact number of "direct reports" can be open to discussion, Drucker wrote that "a basic rule organization is to build the least possible number of management levels and forge the shortest possible chain of command", and that "every additional level makes more difficult the attainment of common direction and mutual understanding".

The other main components of the Google organization "matrix" structure, according to Smithson, are "function based" and "product based". The first involves a "group for Global Marketing and another for Finance". The second involves, for example, "a group for Cloud operations and another for Artificial Intelligence operations".

Veile et al. also recommend a "flat hierarchy and decentralized decision making in order to promote agility," and say that "in some cases it is necessary to spin-off business units to put them into an entrepreneurial environment".

These views are very much in line with the sentiments expressed in How Google Works and the structure of Alphabet which is a holding company for Google and other subsidiaries. In the 2017 edition of How Google Works, Schmidt et al. wrote that "practicing what we preach in How Google Works gets very difficult when a company gets big." So, creation of Alphabet was announced in August 2015 (other subsidiaries include Waymo self-driving cars). Subsidiaries "have the freedom to operate as they choose and to succeed (or fail) on their own. And with a rigorous internal capital allocation process, their CEOs face similar financial pressures as any other CEO trying to grow a business."

Drucker wrote that "organization become critical, above all, when a small business grows into a medium-size one, and a simple business into a complicated one". "The simple one-product, one-market business faces crucial organization problems the moment it adds even a little diversity or complexity". The creation of Alphabet was recognition of this. Drucker may have approved, as he wrote that "activities that make the same kind of contribution can be joined together in one component and under one management, whatever their technical specialization" and "activities that do not make the same kind of contribution do not, as a rule, belong together". In the case of Alphabet, the most profitable parts of the Google business remained with Google, while the drivers of so-called "moon-shots" became separate subsidiaries of Alphabet.

According to one of Google's earliest employee's "Larry's (Larry Page is a co-founder of Google) vision was always to be something like General Electric (GE)" (Manjoo 2015). Each non-Google subsidiary company under Alphabet is dedicated to solving a technological problem. If Google itself as a subsidiary maintains a mainly matrix organizations structure, Alphabet as a whole has product-based subsidiaries more in line with a simple vertical hierarchical structure that Schmidt et al. proclaim to dislike.

However, the GE conglomerate that Jack Welch had built when he stepped down as CEO in 2001, and supposedly benefited from GE's special management approach, is now seen as one that had too many diverse products and attempts have in been made in recent years to focus on a narrower range of products. Siemens in another conglomerate that has been making efforts to streamline with its CEO Joe Kaeser saying in mid-2019 that the conglomerate structure should be a thing of the past—as are "dinosaurs" (McGee 2019).

And the conglomerate structure of Alphabet is not showing great promise at this time, as—according to The Economist magazine in August 2020—"none of the ambitious 'moonshot' projects into which Alphabet has poured billions, such as delivery drones and robots, has been a breakout success". (*The Economist* 2020) It adds that "by some calculations, Alphabet is worth $US100bn less than the sum of its parts".

Moreover, according to The Economist: "The freewheeling ethos that was so successful in Google's early days has become a liability. It works much less well at scale. Google now has nearly 120,000 employees and even more temporary contractors. Doing things from the bottom up has become harder as the workforce has grown larger and less like-minded, with squabbles breaking out over everything from gender politics and the serving of meat in cafeterias to Google's sale of technology to police forces."

So, the "smart creatives" so lauded by Schmidt et al. have a weakness! Google may be learning that Drucker was right when he wrote that "the only things that evolve in an organization are disorder, friction and malperformance".

Veile et al. say that "interdisciplinary project teams should be formed, which consist of software developers, engineers and experts from the areas of sales and business development".

Schmidt et al. suggest taking this interdisciplinary approach to the highest level. They says that the most senior people in the company should be "product people". "When the CEO looks around her/his staff meeting, a good rule of thumb is that at least 50% of the people at the table should be experts in the company's products and services and responsible for product development. This will ensure that the leadership team maintains focus on product excellence. Operational components like finance, sales and legal are obviously critical to company success, but they should not dominate the conversation."

The history of management suggests it is difficult to argue with such a perspective. Drucker wrote that "in a business that wants to innovate, product development is a key activity" and "should not be subordinate to any other activity".

After noting that Steve Jobs was more noted for his leadership skills than technical skills, Saqib et al. say that "there should be a specialized leadership style to be adopted in Industry 4.0 to accelerate the process of innovation and learning". They say that while "transformational leadership is the most commonly discussed", Industry 4 "needs something more" which "should be more specific to learning and innovation". They then refer to the "knowledge leadership construct" which combines the transformational and transactional styles of leadership, and then suggest testing and then adding "innovative role modelling, stimulating knowledge diffusion, supportive behaviour, delegation, consulting and mentoring". They conclude that "this extended construct of knowledge orientated leadership"—which to this writer seem not much more than a listing of generalized platitudes—"can facilitate the organization to accelerate the pace of innovation and learning in the organization to be compatible" with Industry 4.

This would seem to be very much in line with the thinking in How Google Works and the recommendations of Veile et al. They say that "corporate culture and the way communication is set up should support Industry 4.0 without constraints". Among other things, "corporate culture should be characterized by flexibility, openness, willingness to learn and an entrepreneurial mindset. Changes of the corporate culture should be initiated and exemplified by top management in an incremental and top-down process. Communication is to be opened up so that employees are able to freely communicate and discuss across both hierarchical levels and organizational borders".

Much the same can be said for the section on human resources (HR) in Management Approaches for Industry 4.0: A Human Resources Management Perspective. Saqib et al. say that in Industry 4, "managers need to design these HR practices with the intention to promote innovativeness and learning in the organization". They then provide thoughts under the headings of training, staffing, compensation, performance appraisal and job design.

Training recommendations include increasing the variety of skills of individuals, problem solving, mentoring, and team building and team work skills. Staffing recommendation include "spending considerable effort in selecting the right candidate for every job by using extensive recruitment and selection procedures". The authors of How Google Works certainly agree with this latter point, saying that the "single most important thing" that a "manager" does at work is "hiring" and "nothing is more important than the quality of hiring"; and that "he most important skill that any person can develop is interviewing".

Saqib et al. suggest that "openness to new experience" and a "learning orientation" should rank ahead of "performance orientation" when hiring The authors of "How Google Works" write about finding and hiring a "learning animal" because "the world is changing so fast across every industry and endeavour that it's a given the role for which you're hiring is going to change".

On compensation, all that is offered Saqib et al. is a suggested link between performance and reward. A performance appraisal system which "could suit Industry 4", according to the report, "should focus on employee developments, result based approach, behaviour based approach, as these approaches can facilitate learning and innovation". It then suggests a management by objectives (MBO) approach—that is, a clearly defined objectives agreed by both management and those who work at a lower hierarchical level. "Job design to promote the climate of innovation in learning", according to the report, "should be characterized by job rotation, flexible assignments in multiple areas, the extensive transfer of tasks and responsibilities to the employees".

The authors of How Google Works say that "once you get the smart creatives on board, you need to pay them: exceptional people deserve exceptional pay". However, they reject an explicit connection between a specific performance and reward. As well as questioning the Saqib et al. "link between performance and reward", they also would seem not to endorse the MBO approach.

At the time of writing, Google allowed its engineers to spend, within limits, "20% of their time on whatever they choose". However, Schmidt et al. stress that "we don't pay people for successful 20% projects … for the simple reason that we don't need to: it may sound corny, but the reward comes from the work itself. Several studies have shown that extrinsic rewards don't encourage creativity, and in fact hinder it, by turning a inherently rewarding effort into a money-earning chore."

A section on "focussing short-term innovations but long-term capabilities" by Saqib et al. says that Industry 4 "is characterized by short development periods", so "in simple words organizations and employees should be capable enough to change their direction according to the changing circumstances".

The authors of How Google Works certainly agree, saying: "New ideas are never perfect right out of the chute, and you don't have time to wait until they get there. Create a product, ship it, and see how it does, design and implement improvements, and push it back out. Ship and iterate. The companies that are fastest at this process will win."

Amazon claims to have a similar philosophy with Werner Vogels, it global chief technology officer, recently saying: "There are two types of decisions. One is irreversible — selling your company or selling your car. Most decisions, however, are reversible. Think about starting a new service, building a new product or changing your pricing. If you can back out of things, you don't need to have big, slow, deliberate decision-making. You have already 70 per cent of the information, you can really just get started because you can back out if things don't work out. And that allows us to move really fast because we can get started way before all the information is in."

The section on "willingness to abandon investment and knowledge" by Saqib et al. says that "in the uncertain Industry 4 environment, development periods and innovation periods need to be shortened, so there is a need to cut off the traditional style of investment". "Instead of using outdated knowledge, and other resource, organizations should acquire new knowledge, translate the acquired knowledge into core competence, and then develop new products based on the core competence".

Management consulting company McKinsey, when discussing its broad concept of "digitalization" in a 2015 report wrote: "Given the speed with which new innovations, new markets, and new disruptions appear, creating a five- or ten-year plan is becoming an exercise in futility. Long-term forecasting exercises are less relevant and reliable, while agility is more critical than ever" (McKinsey 2015).

Werner Vogels agrees: "Large enterprises need to start behaving like start-ups as well. They need to develop really fast, otherwise they will be disintermediated. And I've always said that about Amazon as well. If we stop innovating, we'll be out of business in 10 to 15 years. And not because there's another large Amazon stepping up; it will be death by a thousand cuts. Someone will be doing shoes better, someone will be doing diapers better. In many traditional businesses today we see that happening everywhere. So enterprises need to move fast as well. And one of the biggest advantages we have given to companies is the ability to move fast (via Amazon's cloud infrastructure Amazon Web Services)."

Drucker wrote that "it is as important to decide when to abandon an innovative effort as it is to know which one to start"—that is, to be able to "admit that what seemed a good idea has turned into a waste of men, time, and money". He also wrote that "near-success can be more dangerous than a failure. There is, again and again, the product or the process that was innovated with the expectation that it would 'revolutionize' the industry only to have it become a minor addition to the product line, neither enough of a failure to be abandoned nor enough of a success to make a difference".

He also wrote that "there is the innovation which looks so 'exciting' when work on it begun, only to be overtaken, during its gestation period, by a more innovative process, product, or service". This may be of greater importance during the present burst in Industry 4 innovation.

And, in what could apply to the uneven development of AI over time, Drucker wrote that an innovation "does not proceed in a nice linear progression".

The authors of How Google Works certainly agree with the above views, saying: "To innovate you must learn to fail. Learn from your mistakes. Any failed project will yield valuable technical, user, and market insights that can help inform the next effort." However, they are less concerned about sticking to "core competence", and this was one of the reasons for the creation of Alphabet as a holding company with various subsidiaries. Core competencies generally were left in Google as a new subsidiary of Alphabet, but other less core endeavors or "moonshots" and "bets" such as Waymo driverless cars are separate subsidiaries.

Amazon's global chief technology officer, Werner Vogels, recently noted that "good things come out of failure" when referring to the company's failure to successfully enter the smartphone market. He said that "we learned many things from that operation, which was amazing".

Overall, Smithson was positive about the Google organizational structure, but suggest that while it is "effective in supporting flexibility in human resources" the "business applies corporate standards that limit overall flexibility in customizing products to suit customer preferences based on regional and local market conditions".

Veile et al. make a separate point about meeting the needs of customers. One of their recommendations is that companies connect horizontally across the value chain. "In order to optimize processes across the entire value chain, data exchange from customers to suppliers and vice versa should be allowed. The principles of openness and trust are essential in cross-company cooperation. Depending on the specific case, temporary cooperation, networks, strategic alliances or coopetition may be adequate. These can be used to develop new business models based on novel value propositions and intensified customer relationships."

This "customer" approach seems to be the case with Apple under Tim Cook, who succeeded Steve Jobs as CEO in 2011. According to his biographer, Jobs did not regard Cook as a "product person" (Mickle 2020) and was regarded as a "relative stranger to creative endeavors". Cook's critics say that instead of creatively looking for new products, he has "found success building products around the iPhone, with a watch, headphones and music- and TV-subscription services" and that "Apple's strong hold on customers who continue to buy new iPhones masks weaknesses and creates a risk that they may miss the next evolution in technology".

In reading this, one might think of the negative consequences of Eastman Kodak's attachment to its very profitable photographic film line of business at the expense of embracing digital film technology.

While Cook "tends to assess new product ideas with caution, taking the position in some discussions that he doesn't want to release a product that may sell poorly and undermine the company's track record of success, according to senior engineers". "Tim, who is a processor. He likes to listen a lot. Time and patience are his favorite warriors."

The authors of How Google Works agree. "Reaching the best idea (for the company and rallying around it) requires conflict. People need to disagree and debate their points in an open environment, because you won't get buy-in until all the choices are debated openly. They'll bubblehead nod, then leave the room and do what they want to do. So to achieve true consensus, you need dissent. If you are in charge, do not state your position at the outset of the process. The is to make sure everyone's voice is heard, regardless of their functional role, which is harder to achieve when the top dog puts a stake in the ground."

Drucker wrote that "the first rule in decision-making is that one does not make a decision unless there is disagreement". The main idea here is to avoid group-think, but "above all", according to Drucker, "disagreement is needed to stimulate the imagination".

The final recommendation of Veile et al. is that "Industry 4.0 implementation process needs to be planned and technical solutions need to be developed and implemented". Moreover, the process of learning how best to use new technology should not be too rigid. "Pilot projects and use cases pave the way to build up knowledge centrally and later on allow transferring Industry 4.0

to other application contexts and scenarios. Both systematic approaches and trial-and-error methods help to develop goal-oriented solutions."

Both Drucker and the Schmidt et al. would agree with this. Drucker wrote that "the first applications (of new technology) are rarely the applications that, in the end, will turn out to be the really important ones". Schmidt et al. wrote that "most of the world's great inventions started out with entirely different applications" than were initially expected.

4 Conclusion

My overall view is that all the discussed publications concerning or touching on Industry 4 have snippets of what good management should focus on, but the ideas are mostly too general—in the cases of Veile et al. and Saqib et al.—or too sector specific as in the case of Schmidt et al.

More traditional management skills and ideas, as exemplified by Drucker, will still have a place in Industry 4. For one thing, there will be many more mundane tasks in the Industry 4 sector, including those best done by people with a strong "performance orientation" rather than a creative bent. Industry 4 involves many physical products—such as robots, 5G infrastructure and autonomous cars—that still need to be manufactured, transported and installed.

Reasonably sophisticated management as a process—if not as a profession—has been around for a long time. Drucker noted that "management as a practice is very old. The most successful executive in all history was surely that Egyptian who forty-seven hundred years ago or more, first conceived the pyramid – without any precedent – and designed and built it, and did so in record time".

But, basic human nature has shown little sign of change. As Napoleon Bonaparte succinctly put it: "There are two levers for moving men – interest and fear". What has changed since the Bronze Age and the construction of the pyramids is technology, and beginning with the First Industrial Revolution and the evolution of written ideas and practices to manage those two levers.

Management ideas have generally moved past the engineering orientated command and control systems of the First Industrial Revolution and in recent years veered into the psychological hyper-sensitive in many areas, but ultimately in this writer's view, the "performance" that is the province of most people will be needed to realize the ideas of the smart-creatives.

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Artificial Intelligence—Reducing the Carbon Footprint?

Ekaterina I. Shumskaia

1 Introduction

Digital technologies continue to penetrate all stages of the manufacturing process. Recent advances in the Internet of Things and Smart sensors, robotics, Blockchain technology, Artificial Intelligence and Big Data open up additional opportunities, but also pose new challenges for society.

The key technologies of the Fourth Industrial Revolution - Artificial Intelligence (AI) and Machine Learning (ML) - can be defined as the ability of intelligent systems to perform creative functions that have traditionally been considered the prerogative of humans. And although today existing intelligent systems have very narrow areas of application, the opportunities that open up are truly unique.

On the one hand, Smart systems will contribute to increased productivity and economic growth. They could also help with achieving significant results in the implementation of modern environmental initiatives to reduce the carbon footprint. On the other hand, the wide range of capabilities of Machine Intelligence forces scientists to comprehensively study the impact of AI on the economy, society and the environment in order to develop preventive measures to mitigate the possible negative consequences of accelerated technological development.

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Given the speed of development of ML and AI, the opportunities offered by the implementation of these innovations in production processes, it is necessary to assess the nature of the impact of technological change on the climate. Are changes for the better possible and are there any barriers and challenges? The study will further explore key areas in the energy and manufacturing sectors in which AI and ML technologies can be applied to reduce the negative impact on the environment.

2 Methodology

The study uses a set of methods, including the analysis of various kinds of sources and analytical materials, information synthesis, data comparison and induction. Actual data was taken from reports of analytical agencies such as PwC, IRENA, Deloitte, IPCC, ERI RAS. The work also used publications and empirical data from the OECD, World Economic Forum, National Geographic and the results of research by leading authors in the field of the impact of technological development on the climate and the environment in general.

3 Results

One way to measure economic progress over the past 150 years is the degree to which it is automated. In the First Industrial Revolution, steam was used for this, then electricity. Relays, transistors, integrated circuits, semiconductors and ICTs were developed afterwards. It can be assumed that AI is only the next phase of the automation process, and not a discrete gap in the course of technological development. Although until recently automation was mainly amenable to routine or low-skilled tasks, mainly due to economic feasibility, the expanding capabilities of AI open up prospects for automating work of a completely different level, performed by already highly skilled workers.

***CO_2* emissions**. The industrialisation process has led to many of today's environmental problems, including climate change and excessive air pollution. Therefore, one of the main goals of modern environmental initiatives is to reduce carbon dioxide emissions into the atmosphere. There are three categories of emissions: direct emissions from internal combustion engines; emissions from the consumption of traditional sources of electricity; indirect emissions arising from the transportation of goods and electricity consumption.

The task of reducing the carbon footprint is on the agenda of many countries, which is already taken into account in the forecasts given by IRENA (the International Renewable Energy Agency). With the current approach to solving the problem, in the period from 2015 to 2050, the amount of emissions will be reduced from 1380 to 1230 Gt (decreased by 11%). Unfortunately, National Initiatives to date are not showing the desired results, and

Table 1 The parameters of consumption of fossil fuels and foreign economic activity in the world

	2015
Primary energy consumption	13,578 mln toe
— Share of all RES in primary energy consumption	23%
Consumption of petroleum products	4267 mln toe
Gas consumption	3571 bln m^3
Coal consumption	5484 mln tfe
CO_2 emissions	31,918 mln t

Source ERI RAS

current energy-related carbon dioxide emissions have grown by an average of 1.3% per year over the past five years (IRENA 2019).

The share of renewable energy sources (RES), which include solar, wind energy, energy of tides, waves, etc., is only 23% of world consumption. According to various development scenarios, this figure will increase and be from 35 to 49% by 2040, which still leaves fossil fuels as the main source of energy (Table 1).

Since 1965, about 35% of all carbon dioxide and methane in the energy sector, or 480 billion tons of carbon dioxide equivalent, have been produced by only twenty companies worldwide. Moreover, twelve of these twenty companies are state-owned, and they account for 20% of all emissions for the specified period (Taylor 2019).

The impact of Artificial Intelligence on the economy. AI and ML technologies continue to evolve and attract more attention and investment. To date AI startups have attracted about 12% of all private investment in the world in the first half of 2018 (3% in 2011) (OECD 2018).

Rapid advances in high-bandwidth hardware, an increase in the number of available Data sources, the development of high-speed Internet and Smart sensors connectivity continue to increase the economic value of AI, reaching up to $15.7 trillion by 2030 (PwC 2017), more than today's the volume of production of China and India combined.

By increasing productivity through the automation of business processes (including the use of robots and autonomous vehicles), improvements in the workforce using Artificial Intelligence technologies (assisted and augmented intelligence) could generate about $6.6 trillion. At the same time, the growth in consumer demand as a result of the availability of personalised and better products and services using AI could contribute about $9.1 trillion. In the short term, the economic potential of introducing AI technologies will be revealed precisely by increasing labor productivity, mainly due to the widespread automation of routine tasks (Fig. 1).

According to the PwC Index of the Impact of AI on Economic Sectors (PwC 2017), the most affected are healthcare (3.7), the automotive industry

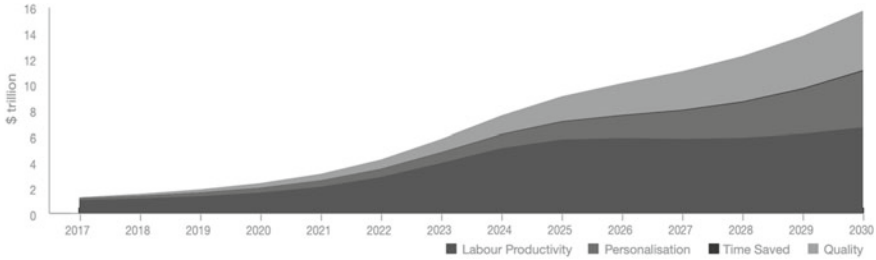

Fig. 1 Impact of AI on world GDP, trillion dollars (*Source* PwC, 2017)

(3.7), the financial sector (3.3), logistics and transport (3.2), and the energy sector (2.2) and the manufacturing sector (2.2).[1]

AI and climate change. Thanks to automation and the introduction of AI, additional opportunities appear for harmonising production and consumption of energy in real time, increasing the efficiency and reliability of the use of renewable energy sources, reducing unpredictability due to the use of Smart sensors (WEF 2015). A shift to increasingly electrified transport modes is also expected. Unlocking the potential of AI is estimated to provide up to 60% of the energy-related CO_2 emissions reductions needed to put the world on track to implement the Paris Agreement (IRENA 2019).

Given the speed with which AI technologies are advancing, we are wondering what impact they might have on the climate (Rolnick et al. 2019). Are changes for the better possible and are there any barriers and challenges? The study will further explore key areas in the energy and manufacturing sectors in which AI and ML technologies can be applied to reduce the negative impact on the environment.

Electricity production and use. AI and ML technologies can reduce emissions in the energy production and supply sector, especially for renewable energy sources, by increasing the reliability of systems. There are a number of successful projects for the implementation of Artificial Intelligence and Machine Learning technologies (Russeull 2019).

For example, AI providers such as Google's DeepMind say they can improve the efficiency of renewable energy using their own wind farms, where AI has increased efficiency by 20% (Elkin 2019).

Technology can also help reduce dependence on fossil fuels. For example, at the think tank Carbon Tracker, AI is being used to monitor emissions from coal-fired power plants using satellite imagery in order to achieve the UN goal of preventing the construction of new coal-fired power plants (Snow 2019).

With the introduction of ML and AI technologies, there are significant opportunities to reduce the negative impact on the climate in the field of energy consumption in cities and transport. Thus, according to the 2019 data

[1] The AI Impact Index scores range from 1 to 5, with 5 indicating the greatest potential impact and 1 the least.

for the EU, electricity consumption by buildings is 40% of the total, which, in turn, gives 36% of carbon dioxide emissions (Olsthoorn 2019), and transport emissions account for about 25% of global CO_2 emissions (IPCC 2018). There are a number of possible solutions aimed at reducing the harmful impact on the climate: increasing carbon efficiency by switching to renewable energy sources; increasing energy efficiency; improving the quality of urban planning and other systems; optimisation of trade and sea routes.

Potential challenges of AI development for the climate. The described capabilities of artificial intelligence are incredible, but are these technologies safe for the environment? As with the popular fossil fuel analogy, machine learning also has negative environmental impacts that are rarely mentioned in articles about AI.

Jevons' paradox - a situation where technological progress, which increases the efficiency of resource use, increases (rather than decreases) the volume of its consumption, remains relevant to this day. For example, the convenience of autonomous vehicles can lead to increased use, which will only increase greenhouse gas emissions, while making each individual journey more efficient.

Advances in the training of deep neural networks have recently led to dramatic improvements in accuracy in many fundamental Neurolinguistic Programming (NLP) problems. Until a decade ago, most NLP models could be developed and trained on laptops and servers. Modern models require significant computing resources, which require more energy, which entails additional financial costs and an increased negative impact on the environment (Table 2), which in the future may constitute a significant part of greenhouse gas emissions. The table shows that the plane produces almost 2 times more carbon dioxide per hour than the installation for the development of the NLP model. But if you evaluate emissions depending on the duration of one run, you can see how much harm to the environment AI computers could have.

Perhaps the further development and improvement of RES work will be able to neutralise the negative impact of AI equipment. Thus, in Finland, the largest Data Center will heat about 20 thousand houses. This project

Table 2 Comparative analysis of carbon dioxide emissions depending on the source

	Emissions CO_2, *kg*	*Emissions* CO_2, *kg per hour*
One round trip flight (New York - San Francisco)	900	163
Average person per year	5000	0.6
One petrol car for the entire time of use	57,152	0.8
Training one model with neural architecture search	284,019	94

Source Calculated by the author based on data from Strubell E. et al., 2019 will reduce CO_2 emissions by 103 thousand tons, which is equivalent to 55 thousand vehicles (Business Finland 2020).

But there is another barrier: the need for resources and raw materials for the production of equipment. With the growing diffusion and application of digital technologies, the demand for raw materials is also increasing, raising questions about their availability. Thus, in a study by the German Mineral Resources Agency DERA, it is predicted that in 2035 the most demanded materials on the market will be lithium and heavy rare earth elements (Marscheider-Weidemann et al. 2016).

4 Conclusions

Many scientists and researchers say that the technologies of the Fourth Industrial Revolution will make a significant contribution to increasing labor productivity and increasing economic growth. At the same time, the issues of the consequences of technological development remain unexplored, and it was precisely the previous stages of industrialisation that led to many modern environmental problems, including climate change and excessive air pollution. Therefore, it is important now to study the impact of breakthrough technologies, including AI, on the economy, society and the environment.

Many studies demonstrate the significant potential of AI and machine learning technologies to change the environmental situation for the better. At the same time, a number of challenges are extremely rarely mentioned: the Jevons' paradox, an increase in the need for various resources, both for assembling computers and for powering them, which, in turn, leads to colossal volumes of emissions from installations. And even if point solutions for some problems arise, then in the future an integrated approach to the analysis and formation of preventive measures to mitigate the possible negative consequences of accelerated technological development is required.

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On the Use of Climatic Information in Automated Business Processes of Industry 4.0 Enterprises

Evgenii D. Viazilov

1 Introduction

British experts, led by the economic adviser to the government, Nicholas Stern, noted: "Man is not given the ability to reverse hurricanes, earthquakes and other natural disasters, but he is quite capable of implementing preventive measures that will minimize human losses and economic damage, while at the same time ensuring the fastest and least costly return to normal life. Inaction will cost much more—in an amount equal to the losses of humanity from both world wars, the Great Depression of 1920–1930, and the current global economic crisis".

Information on the consequences of climate change should be transferred from the plane of discussions about the trend (positive or negative) and the magnitude of changes, main factors of these changes into the plane of society's adaptation to these changes, by identifying of impacts and issuing recommendations for decision-making in order to reduce or prevent these impacts. Together with the consideration of various "scenarios" of climate change, it is necessary to develop and implement preventive measures before, during and after the passage of disasters.

Certain work is in Russia in this direction. The "Climate Program" approved by the President. "Strategy of activities in the field of hydrometeorology and related areas for the period up to 2030 (taking into account aspects

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of climate change) is approved by Government" ("Order of the Government of the Russian Federation". No. 1458-p of September 3, 2010). National and regional plans for adaptation to climate change are developing, safety data sheets for enterprises and territories are preparing, and technologies for communicating warnings about disasters to the heads of enterprises are improving.

The impacts of disasters depend on the level of economic development, lifestyle and cultural traditions of the country (Assessment … 2008). More people perish in developing countries, but the economic damage is greater in developed countries. For example, based on an analysis of the table of estimates of damage from extreme weather impacts and climate change for the European Union (Gardner et al. 2016), it can be concluded that the greatest economic losses occur in advanced economies (Germany—92,144, Italy—61,778, France—60,043 million Euro). The main reason for the increase in losses is the development and complication of the management of economies of countries, especially transport systems, agriculture, housing and communal services and other enterprises. The growing dependence of mankind on disasters is also explained by intensive development of sea shelves for the extraction of oil, gas and other minerals; construction of new large, expensive enterprises (tankers, drilling platforms, aircraft); lack of automatic methods for the continuous accounting of indicators of disasters for decision-making.

Domestic and foreign experience shows that the damage from disasters is associated not so much with the inability to prevent their consequences, but with insufficient awareness and taking into account the available information. There is no scientifically substantiated understanding of the need and sufficiency of information for taking preventive measures. The relationship between the economic performance of enterprises and changes in the state of the environment has little studied. The increase for information provided to enterprises heads has further complicated the choice of preventive measures taken in the face of time pressure and stressful situations.

In 2014, the World Meteorological Congress proclaimed: "Predicting of disasters impacts on enterprises is one of the activities of the National Hydrometeorological Services". The prospective development of specialized hydrometeorological support (HMS) should provide for the transition from the concept of informing consumers about the current situation to a recombeen actively usedmendatory concept (Khandozhko 2005). Main difficulties in generating impact predictions are following:

- lack of automatic disasters detection based on local threshold values for various enterprises and communication of information about disasters to managers;
- significant, and sometimes simply unacceptable for making decisions, delivery time of information;
- lack of formalization of information about the possible disasters impacts on enterprises;

- recommendations on preventive measures to reduce or prevent impacts of disasters on enterprises are not collected and classified, they are not divided into actions before, during and after the event;
- insufficiently legal norms in the relationship of institutions researching the environment with the heads of industrial enterprises developed;
- lack of legal measures of responsibility of enterprises leaders for failure to use hydrometeorological information (HMI) or failure to take actions to prevent damage;
- absence of a closed cycle from measurements to decision-making.

Barriers to the use of climate information include: low demand for climate information from enterprises leaders; insufficient integration of heterogeneous and distributed data; the variety of formats in which data is transmitted and the variety of information sources, its presence in atlases, reference books, and regulations, for examples, (SNIP 2.06.04 1986; RD 52.27.881 2019; Atlas 2011).

In almost every enterprise, there are activities that depend on disasters. Optimizing the dependence of this activity on disasters allows building a number of business processes associated with solving problems of local, regional and even national scales. An example is aviation or maritime transport, where HMI has been actively used for many years. The disadvantage of the existing HMS is that the process of using the HMI is not automated enough. Sectors of the economy are actively developing and must take into account the current conditions in the hydrosphere, atmosphere and lithosphere, as well as forecasts of possible impacts on activities of enterprises, contributing to the adaptation of enterprises to climate change. Most business processes using HMI use individual decision support elements in the form of geographic information systems (GIS), or assessment models of situation, or the issuance of unformalized text for individual disaster.

The development of the Internet, info communication technologies, communication channels, cloud technologies and digital platforms ensured the emergence of open databases, networks that go beyond boundaries of an individual enterprise and interact with each other and other IT-achievements. This is the fourth stage of industrialization (Industry 4.0), which provides for data integration, end-to-end automation of all stages of data processing.

Basic principles of building Industry 4.0 are in (Tarasov 2018): compatibility (the ability of machines, devices, sensors and people to interact and communicate with each other); transparency (obtaining the most complete information about all processes that take place in enterprises); decision support (help enterprises heads in making decisions); decentralization of managerial decisions—delegation of some functions of the decision support system (DSS).

Industry 4.0 includes the development of safe cities, smart buildings, self-driving cars, drones, automated factories, etc. Unfortunately, these designs rarely include GMI accounting. The paradoxical situation emerged when the collection, accumulation, applied processing of data, obtaining climatic generalizations, short-term, long-term and ultra-long-term forecasts of Hydrometeorological Centre (HMC) and climate change are available, and their use does not always increase the efficiency of production processes, which is one of most important indicators of the Industry 4.0.

2 Methodology

To increase the efficiency of using HMI in production processes, it is necessary to develop a modern HMS system of enterprises, which should include following components: integration of heterogeneous and distributed data, automatic detection of disasters, selection and transmission of information about disasters to enterprises; presentation in a compact and informative form of information about the state of the hydrometeorological situation in the form of an "Dashboard"; detailed presentation of the HMI in the form of the "MeteoMonitor" application, bringing information to external information systems of enterprises, decision support, damage assessment and calculation of the cost of preventive actions before disasters; optimization of the solution by choosing a solution from several alternative ones. The technological scheme of data integration, processing and use is shown in Fig. 1.

2.1 Data Integration

It is possible quickly develop digital services only based on a single platform, using tools for integrating distributed and heterogeneous data. In order for

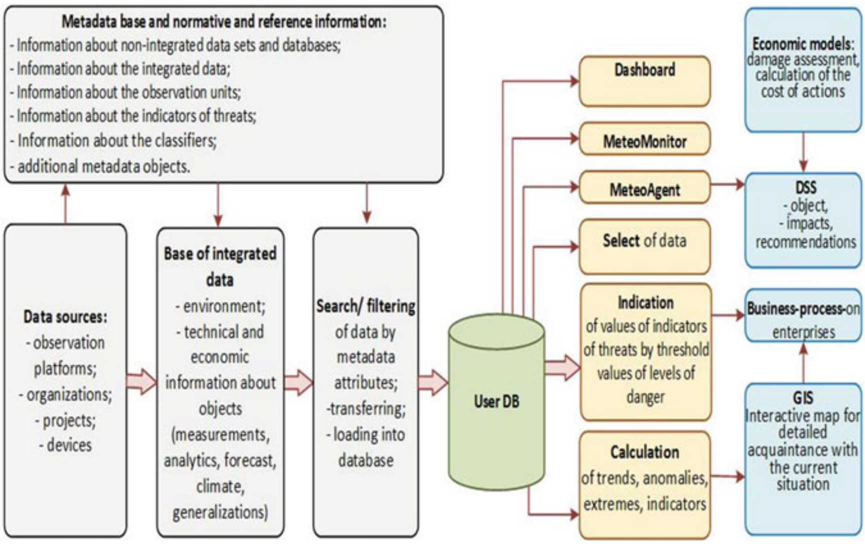

Fig. 1 Technological scheme of integration, processing and data use

distributed, heterogeneous data to be available for use from one or more sources, through one interface, that data can were easily exchange, delivery to any consumer automatically, it must be integrated. An example of such a system is Unified State System of Information on the Situation in the World Ocean (ESIMO[1]). Main decisions on the creation of the ESIMO presented in the article Vyazilov et al. (2013). It remote input of metadata; application of common codes and classifiers; use of cross-platform tools—J2EE, XML, AJAX technologies, PostgreSQL database server, JBoss Portal application server, GIS SERVER, GIS visualizer OpenLayers.

2.2 Automatic Detection of Disasters

Enterprises need data when disasters indicators values exceed thresholds for specific enterprise, activities, and dangerous levels. This requires:

- to implement technology for integrated and targeted information services by automatically bringing information about disasters to heads of enterprises and government bodies;
- to develop means of assessing the state of disasters indicators by dangerous levels for enterprises, activities with access to a more detailed consideration of situations (maps of isolines of current, prognostic, climatic data);
- create a database (DB) of threshold values of disasters indicators, taking into account the type of object and types of activity, based on the "traffic light" on the following scale: green—normal situation, yellow—moderately disturbed, orange—dangerous, red—catastrophic.

The input information for determining the threshold values of disasters for objects are values of measured parameters at observations points or nodes of a regular grid. Disasters are distinguished both at the level of the observation point (the excess of the indicator was registered at one observation point) and the region (disasters were registered at several points in space). In this case, both Roshydromet warnings about disasters are used, which are automatically are identified based on observed and predictive data. The result of the work of this block is a constantly updated DB with dangerous situations for each object and type of activity.

2.3 Application for the Selection and Transmission of Information About Disasters

For HMS of consumers it is necessary to use the official "Warnings" issued by the organizations of Roshydromet. These warnings generated by observers or forecasters, transmitted over the Global Telecommunication System (GTS)

[1] http://esimo.ru.

and loaded into an integrated DB. In the first variant, information about disasters detected by observers at the hydrometeorological station and transmitted in the WAREP code. These messages can use to identify objects that affected by identified disasters, using threshold values of the metrics for the objects in question. The second variant is when forecasters in forecast centers, based on an analysis of the current situation, forecast maps and other materials, give disasters forecast and transfer it to interested enterprises.

It should be possible to reconfigure the composition of monitored disasters and threshold values of indicators for a particular enterprise. When disasters identified, the cause of its occurrence is established. Knowledge of causes of disasters allows predicting its development and the emergence of new disaster, the cause of which may be the first disaster. The organization of automatic communication to managers of information about disasters is designed to increase the awareness of enterprise leaders, quick acquaintance with the current situation. For this is use:

- automatic indication of disasters indicators in the form of “traffic lights” for different levels of danger;
- selection and transmission of received storm alerts;
- transmission of information about disasters, including the provision of information on impacts and recommendations for decisions support;
- issuance of information on possible damage and costs of preventive measures;
- displaying the state of indicators of the situation for a specific object in the form of “Dashboard” application.

“MeteoAgent” application is designing to visualize information about disasters based on the received SMS message with links to “Dashboard”, “MeteoMonitor” applications for obtaining more detailed information about the current situation and the application for decision support. These applications are installing on the manager’s computer and automatically activate upon receipt of an SMS message from the “Data communication” software component.

2.4 “Dashboard” and “MeteoMonitor” Applications

In addition to an SMS message, the enterprise head should see the status of indicators about the current situation. An application for visualizing indicators in the form “Dashboard” should use. “Dashboard” application configure by the consumer for a specific object, hydrometeorological station or geographic area, threshold values of indicators. Each of the types of economic activity has its own limitations, which may not coincide with general gradations established in existing regulatory documents (RD 52.27.881 2019; RD 52.88.699 2008; Regulations … 2016).

The application shows changes in the values of observed and prognostic parameters marked on icons of devices, indicating the level of their danger. Next to each parameter, there are graphs of their changes for last 5–10 periods, as well as anomalies and trends. When data in the sources update, the data on "Dashboard" application automatically kept up to date. In such an application, information displayed in a more compact form on the screen. In addition, one glance at this form of display is enough to understand the current situation.

If necessary, the enterprise header can get detailed information on an interactive map using the "MeteoMonitor" application on the ESIMO portal for the region, which displays the dynamics of changes in indicators in space and time, Vyazilov et al. (2013).

The "MeteoMonitor" program interface must provide the following forms of information presentation: lists of messages about disasters; maps of the distribution of disasters in space; graphs of changes in indicators over time; tables of parameter values at specific observation points or nodes of a regular grid closest to the object; the results of the indication of values showing the state of indicators for individual objects and types of activity; means of signaling about danger by sound and color.

2.5 Loading of Information into External Information Systems

Currently, it is necessary that data on disasters be used in automated business processes of enterprises for their constant accounting, for example, wind speed and direction must be taken into account when unloading coal in a seaport located in the city. The enterprise head subscribes to the delivery of the necessary data. Depending on the business process, data can be supplied for a point, or area or trajectory. Means of delivering information to consumers include subscribing to data and posting it on remote ftp servers or sending data by e-mail; to news feeds for documents, news, messages, telegrams received via GTS.

To develop business processes that are solved using HMI, it is necessary to clarify the indicators that affect the execution of business processes; to identify hazardous situations based on threshold values of indicators obtained on a regular basis; to deliver information about disasters to object and load values of indicators into DB.

For the efficient data delivery, the following capabilities should be implemented:

- loading data directly to DB of information systems of enterprises, rather than uploading it to e-mail boxes or to ftp-servers;
- data delivery upon data update for event;
- instant receipt of notifications for any disruptions in delivery for their immediate elimination, avoiding the impact of the consequences on business processes of consumers;
- monitoring all data deliveries to assess their compliance with settings.

2.6 Decision Support System

The DSS application is intended to visualize information about disasters based on the received SMS message with the application address to obtain a list of possible impacts and recommendations (Vyazilov 2017; Viazilov 2019), as well as links to applications for damage assessment and cost calculation of preventive actions. The main idea of creating DSS is as follows. Knowing environment conditions is possible to determine in advance the list of impacts on enterprises. Knowing impacts, can determine the recommendations for decision-making. To develop such a system, it is necessary to solve following tasks:

- collection, formalizing, enter into DB and store of information about impacts of various disasters on enterprises;
- formalizing of recommendations for decision-making, taking into account possible impacts for various objects, types of activities, dangerous levels, decision-making levels;
- development software tools for automatic detection, communication and visualization of information about disasters;
- realization means of input, editing and visualization of information about impacts and recommendations, depending on the current situation;
- development of economic and mathematical models for assessing possible damage and calculating the cost of preventive actions before the onset of disasters.

2.7 Damage Assessment and Calculation of the Cost of Preventive Actions

Material damage is assessing in natural and monetary units. In natural units is reported, for example, number of destroyed bridges, houses, industrial buildings, number of deaths; number of sick people; number of wounded, etc.

Potential damage associate with the loss of property of enterprises, cultural values. In addition, damage to the environment is possible. There may be costs associated with claims by injured parties; fines for the consequences of an incident (chemical spill); the cost of restoration work and the elimination of consequences of the incident. Losses from disasters are determining by the termination of certain types of work, loss of cargo deterioration in the quality of transported products; destruction or the need to repair the equipment, a decrease in the book value of fixed assets of objects, a decrease in the output of products, the downtime of an object, increasing in time to complete work. After the disaster need account a cost of salvation; emergency recovery measures; treatment of the wounded; salaries of employees during emergency recovery measures. These costs include the cost of renovating buildings, payments to employees from the social insurance fund for the period of temporary disability, lost profits.

To make a decision, in addition to the possible damage, you need to know the cost of preventive measures. Calculations of preventive measures cost are made up of: salaries of workers involved in preventive actions; rental of equipment for the removal of goods from the disaster zone; construction of temporary enclosing dams, embankments during floods; evacuation of people, forced movement of material and technical means, shelter of materials; expendable materials.

3 Results

DSS does not solve the problem of reducing losses. Only properly constructed business processes will improve the efficiency of decision-making to prevent impacts of disasters. To improve the efficiency of consumers requires:

- identify parameters required for each business process of managing activities of enterprises, as well as characteristics of the state of economic objects;
- determine required types of data, formats for their presentation, time of receipt, possible delay time with the receipt of data for each business process;
- develop methods for assessing and obtaining disasters indicators;
- describe business processes, which will clearly show the time, place, type, form of data presentation from the beginning of the business process to its end;
- improve or develop new methods for forecasting the state of the environment depending on the development of economic and other activities (on a scale—city, district, region, territory, republic, federation) for various industries and activities;
- assess impacts of disasters on economic objects;
- create a DB with time series and gridded data on socioeconomic indicators and hydrometeorological parameters;
- create DB of threshold values of disasters indicators for individual objects;
- create a bank of economic models to assess damages and calculate the cost of preventive actions.

At the same time, it is necessary to develop software tools that allow:

- carry out regular analysis of current data to identify exceeding threshold values of disasters indicators for each type of economic objects;

- to obtain combined graphs of changes in environmental parameters and the state of equipment at enterprises in time for visual analysis and forecast of impacts;
- to plug models to assess impacts, including assessing potential benefits or damages, clarifying recommendations for decision-making;
- create a personalized place for enterprises leaders, which will receive all the current, diagnostic, predictive and climatic information necessary for the selected enterprise for making current, tactical and strategic decisions.

The DSS design stages include: study of information needs, sources, formats and dissemination methods; assessment of adaptation methods; building risk maps, descriptions to increase consumers awareness of the range of available data, information and formats; support and updating of services; development of business models for continuous assimilation of HMI; development of feedback mechanisms with consumers. Methods of obtaining data using pre-prepared ready-made visual Dashboards on the principles of "self-service" should be replaced by fully automatic schemes for receiving, delivering, loading into DB, aggregating, analyzing, displaying data, identifying disasters with an indication of the dangerous level. The new tasks of HMS should be:

- automatic notification of enterprises headers about impending disasters and the issuance of information about possible impacts and recommendations for taking preventive actions via a mobile Internet device;
- inclusion of the GMI in the information system of enterprises, for example, in the navigation system of a vessel and the combination of the route of the vessel and designated areas of passage of disasters based on current and forecast data;
- accounting of threshold values of hydrometeorological parameters when some objects, for example, unmanned aerial vehicles, are in disasters area.

Business processes that can solved using HMS are efficiency assessment based on weather conditions, business process modeling based on HMC forecast, predictive analytics to ensure hydrometeorological safety. These are areas where need to support making the right strategic and tactical decisions using HMI at the industry, federation, enterprise and individual levels.

It is necessary to determine the activity that needs for manage using HMI; need data for each business process; formats for their presentation, time of receipt, possible delay time with the receipt of data; aggregate and store data. For each object, its own specific regulations must be drawn up for to provide all business processes in which the use of HMI is necessary. Such regulations should include:

- list of indicators of disasters;

- list of operations for the automatic identification of disasters and delivery of information about them to the heads of state authorities, enterprises;
- assessment of damages, calculation of preventive actions cost;
- determination of decision-making criteria;
- sequence of decision making before, during and after the event;
- forms and procedure for monitoring the performance of actions and decision-making and of reporting on the performance of actions or decision-making in the course of exercising the powers of the head of the enterprise or public authority, taking into account the state of environment.

4 Conclusions

The perspective directions of development of HMS of consumers are presented, related to the use of HMI in business processes of enterprises by increasing the level of automation of data processing. The developing IT infrastructure of Roshydromet should ensure the continuity of processes of observations, of collecting data in forecasting centers, of data integration, of exchange and transferring of data to external systems, of delivery of information about disasters to consumers in the form of SMS messages, of data visualization for detailed acquaintance with the hydrometeorological situation, of using information in business processes and making decisions. That is, an end-to-end technology of consumer's service "from observation to decision making" should be implemented.

The use of real-time data from hydrometeorological stations in combination with analytical and forecast data to solve business problems is suitable for the sphere of housing and communal services, transport, production, etc. It is necessary to carry out continuous comprehensive monitoring of the state of the hydrometeorological situation for HMS on all steps of life cycle of the enterprise.

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Global Hydropower as the Main Driver of Sustainable Development in the Context of Industry 4.0

Inna V. Andronova, Vladislav V. Kuzmin, and Arina A. Tinkova

1 Introduction

Hydropower is one of the fundamental, significant and necessary areas of renewable energy industry. It's manifested not just in the colossal amounts of electricity generated through this, but also in the increasing urgent need to withstand natural disasters in the modern world. According to the Hydropower Status Report (International Hydropower Association 2020b) published by IHA, about 15.6 GW of new hydropower capacity was commissioned in 2019, up from 21.8 GW added a year earlier (International Hydropower Association 2019b). Despite the decrease in the power gain, it could be argued that this indicator for traditional power generation is quite high. Moreover, if we turn to historical data (Fig. 1), we could see a rather clear tendency towards an increase in a colossal amount of energy capacities over the past decade.

The field of international cooperation in the energy sector is multifaceted. Current initiatives in hydropower sector have a strong strategic and long-term basis. It's based on innovative technical solutions and modern global trends. At the same time, an economic aspect is viewed not as a business for the transmission of electricity within a particular country, but as a tool for building external relations and a way of potential interaction. Currently, the

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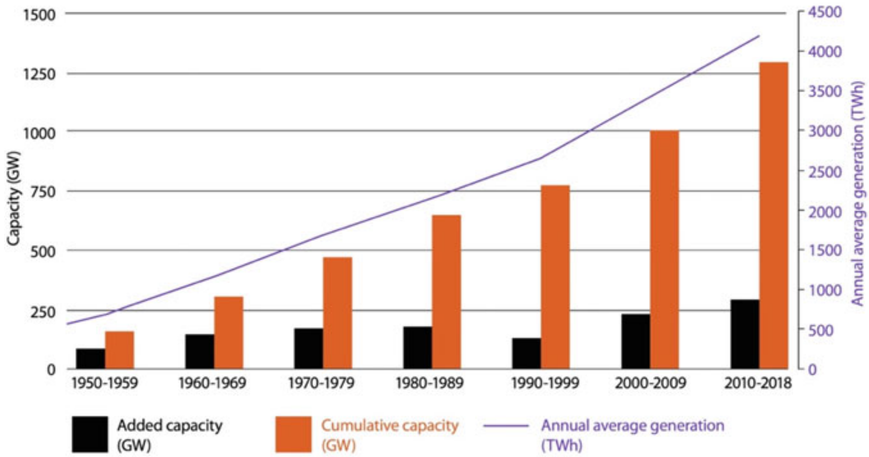

Fig. 1 Installed hydropower capacity growth since 1950 (*Source* [International Hydropower Association 2019b])

Covid-19 crisis is causing turmoil in energy markets, and hydropower isn't immune from these events (International Hydropower Association 2020a). Hydropower could become an integral part of the recovery process and clean energy concepts. It is due to the exceptional storage capabilities and flexible services that can support the integration of variable renewable energy sources (RES) based on it (International Hydropower Association 2020d). Projects in hydropower sector may safely offer clean water for agriculture, homes and businesses and facilitate mitigate the impact of maximum weather events like floods and droughts. These comes could conjointly offer very important transport infrastructure, investment publically services, leisure and recreation. Moreover, so as to maximize the potential contribution of hydropower to the global economy, an inexperienced recovery arrange has been developed as a neighborhood of the world response to Covid-19, involving important new investment from the general public and personal sectors.

2 Methodology

The aim of this paper is to research the possibility of strengthening the position of hydropower in global energy balance as the main engine of sustainable development among renewable energy sources in the context of Industry 4.0.

The study is based on official data provided by international organizations that directly influence trends in the development of international relations in the field of energy policy, in particular, regulators in the field of renewable energy sources and hydropower. It also considered current situation and policies of countries with large hydropower potential, making a significant contribution to the world energy community.

Empirical data, statistics and publications from the World Bank, IFC, UNESCO, UNCTAD, IHA, IRENA, as well as the recommendations of the World Commission on Dams and the Equator Principles were used to estimate the percentage of hydropower potential utilization as an integral part of global renewable energy production. For information analysis, traditional methods and techniques of economic analysis were employed in the shape of examination absolute, relative and average values, beside with the grouping technique.

3 Results

Taking into account global energy trends, it should be noted that hydropower produces more than two-thirds of the world's energy generated from renewable sources (Zhiznin and Timokhov 2017), which directly opens the way to rationalizing the use of world resources in general. Hydropower helps to reduce dependence on harmful energy sources by ensuring that billions of people are able to generate enough clean energy (International Hydropower Association 2019a).

The development of energy sector, with an emphasis on renewable energy sources, based on hydropower, has a positive effect on the problem of climate change in the long term in the context of the fourth industrial revolution (The Ministry of Energy of Russia 2019). According to preliminary calculations (International Hydropower Association 2019a; Bogush et al. 20162016), in order to limit the rise in global temperature to below 20 °C above the pre-industrial level, it's assumed that global hydropower capacity should increase by 25% by 2030 and by 60% by 2050. To achieve 2050 targets, the average annual increase in hydropower capacity, according to estimates, should be about 2.0% per year.

Another fairly effective and at the same time non-harmful source of energy is a pumped storage power plant (PSPP), which is an integral part of hydropower production. This type of power plant, in contrast to a traditional hydroelectric power plant, allows you to take into account the frequency and seasonality characteristic of wind and solar power plants. According to (International Hydropower Association, 2020b), PSPP has a number of clear benefits over alternative types of energy storage grateful to long life of service, its low price, and independence from the supply of raw materials. Numerous studies (International Hydropower Association 2020b; International Renewable Energy Agency 2020; Bushuyev et al. 2017) have revealed great potential for the construction and development of pumped storage power plants around the world. According to estimates (International Hydropower Association 2020b), by 2030 the capacity of this type of power plant will increase by 78 GW, which is significantly higher than the potential increase for other similar technologies. According to the data (Table 1), current global capacity of PSPP is 158.0 GW, 77.2% of which (121.9 GW) are in the top 10 countries in terms of capacity.

Table 1 Global pumped hydropower storage installed capacity by country

No point	*Country*	*Installed capacity, GW*
1	China	30.3
2	Japan	27.6
3	United States	22.9
4	Italy	7.7
5	Germany	6.4
6	Spain	6.1
7	France	5.8
8	Austria	5.6
9	India	4.8
10	South Korea	4.7
*	Rest of the World	36.1
**	Sum	158.0

Source Compiled by authors according to (International Hydropower Association 2020b)

3.1 The Global Cost of Hydropower in the Context of Other Renewables

Based on the calculations (International Renewable Energy Agency 2018b), hydropower is the cheapest source of electricity among all renewable sources, and it also has the largest industrially significant potential (Table 2).

According to data provided by (International Renewable Energy Agency 2018b), it could be argued that hydropower is a very engaging renewable energy technology because of the low value of electricity generated and

Table 2 Global electricity prices by energy source in 2018

Energy source	*Global weighted-Average cost of electricity (USD/KWH) 2018*	*Cost of electricity: 5th and 95th percentiles (USD/KWH) 2018*	*Change in the cost of electricity 2017–2018 (%)*
Bioenergy	0.062	0.048–0.243	−14
Geothermal	0.072	0.060–0.143	−1
Hydro	0.047	0.030–0.136	−11
Solar photovoltaics	0.085	0.058–0.219	−13
Concentrating solar power	0.185	0.109–0.272	−26
Offshore wind	0.127	0.102–0.198	−1
Onshore wind	0.056	0.044–0.100	−13

Source Compiled by authors according to (International Renewable Energy Agency 2018b)

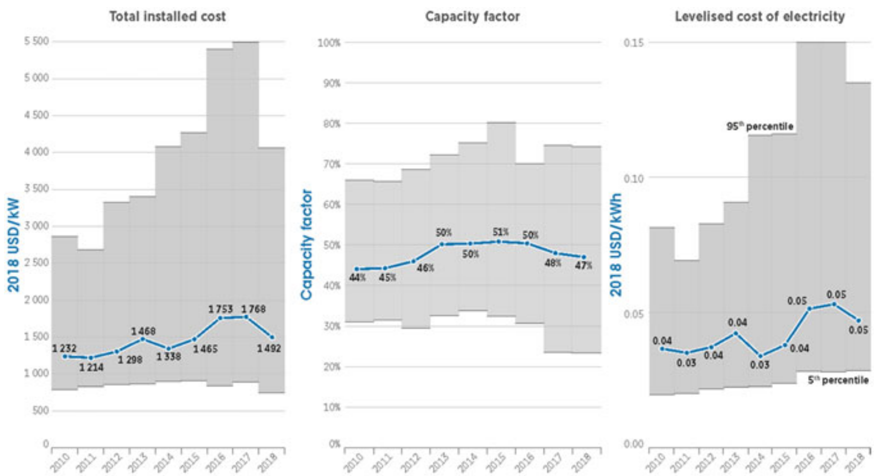

Fig. 2 The global capacity weighted-average total installed cost, power factors and LCOE of hydropower, 2010–2018 (*Source* [International Renewable Energy Agency 2018b])

therefore the flexibility it may give to the power system. The global weighted-average LCOE[1] in 2018 for HPP facilities was USD 0.047 per KWH, which is lower than its indicator in 2017 by 11%.

From 2010 to 2013, the global weighted average LCOE for hydropower was relatively stable before starting to rise to a new, slightly higher level in 2014 (Fig. 2). This was due to the increase in the total cost of the installation in Other Asia.[2] Given the fact, while hydropower could be an extremely site-specific technology and every project is site-specific at intervals a given river basin, the precise reasons for this cost increase are tough to see. While any future analysis is required, the rise in prices in Other Asia was seemingly driven by an increase within the range of projects with costlier development conditions compared to earlier comes where better sites had been developed. Current facilities may be located in more remote locations, farther from the existing network infrastructure, requiring higher network connectivity, access and logistics costs. They could also be located in areas with more difficult geological conditions, which increases the cost of construction. A combination of the factors above may drive future trends in cost formation.

In 2018, the global weighted average total installed cost of hydropower projects fell to USD 1 492 per KW (Figs. 2 and 3), which is 16% below the 2017 value (which was similar to the 2016 value). It remains to be seen

[1] Levelised Cost of Energy—standardized cost of electricity (average estimated cost of electricity production throughout the entire life cycle of a power plant, including all possible investments, costs and revenues).

[2] Other Asia means Asian countries, excluding China, India and Japan, based on the report of (International Renewable Energy Agency 2018b).

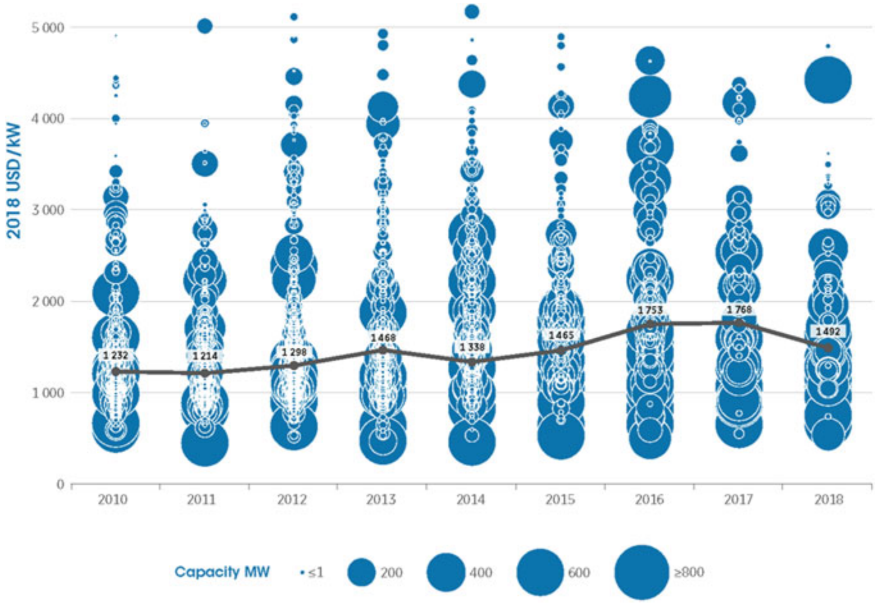

Fig. 3 Total installed costs by hydropower project and global weighted-average, 2010–2018 (*Source* [International Renewable Energy Agency 2018b])

whether or not this fluctuation around a brand-new higher level of average prices or whether or not average prices could still to decline. Much will depend on where future hydropower projects are launched, as one of the reasons for the fall in the global weighted average cost of installed hydropower in 2018 was the high share of comes taken by China (8.5 GW) in total new capacity that commissioned in 2018 (21 GW). It's because installation costs in China are typically 10–20% lower than average.

Small-scale hydropower projects up to 50 MW could provide competitive installation costs of USD 1 500 per KW on average, although the total installation costs for these projects span a much wider range than for large one. However, there is some evidence that projects in excess of 700 MW are showing significant economies of scale. The complete dataset of hydropower projects in the IRENA Renewable Energy Database from 2000 to 2018 (Fig. 4) suggests that the full put in prices of smaller projects cowl a wider vary than larger ones, however from the purpose in terms of preparation, the weighted average installation value isn't considerably lower for bigger projects, with the exception of sizes exceeding about 700 MW. Notwithstanding there's less information, projects within the 250–700 MW vary seem to own slightly higher installation prices than smaller or larger projects. Global weighted-average capacity factors of hydropower projects, that were accredited in 2010–2018 range from 44% in 2010 to a spire of 51% in 2015, before

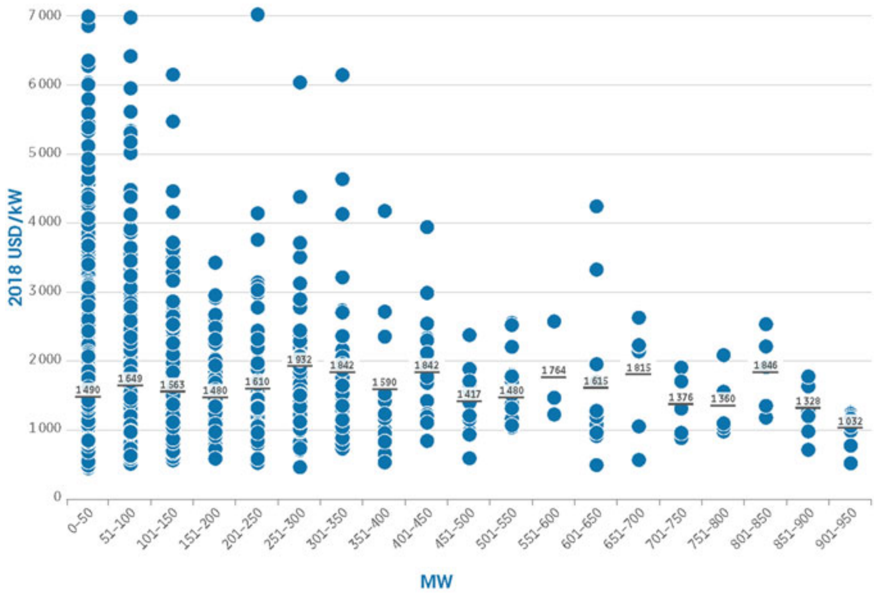

Fig. 4 Total installed costs for hydropower by project and weighted-average by capacity range, 2000–2018 (*Source* [International Renewable Energy Agency 2018b])

prosecution at 47% for projects accredited in 2018 (International Renewable Energy Agency 2018b).

In 2019, a share of renewable energy sources (including hydropower) in the global energy balance increased by 1.1 pp to almost 27%, in line with the upward trend that began in the 2000s.

This growth is preferably due to the launch of new wind and solar power plants, being that since 2000 the share of hydropower in the global energy balance as a whole has remained at 15%. Favorable hydrological conditions have also led to a significant rise within the generation of electricity from RES in China, India, Turkey, Russia, Iran and Nigeria. Renewable energy currently accounts for 35% of the energy balance in the EU, 27% in China, 21% in India and about 18% in the USA, Russia and Japan. At the same time, total installed hydropower capacity in the world reached 1 308 GW in 2019 (International Hydropower Association 2019b). It represents an annual growth of 1.2%.

3.2 *Participation of International Organizations*

The globalization of energy relations has necessitated the emergence of a number of international organizations that are directly involved in the regulation of this area.

Considering that energy is one of the key sectors of the world economy and it has a significant impact on its other sectors, the activities of most international economic organizations directly or indirectly affect international energy relations and relevant legal norms. OPEC and the Energy Charter Conference are examples of direct influence on the development of international energy relations and international energy law. Thus, OPEC, through its impact on the world oil market, influences the state of the international economy and the development of relevant relations, for example, the development of new energy sources, an increase in attention to environmental issues, which in turn is reflected in the direction of their legal regulation.

An example of the indirect influence of international organizations on international energy relations and energy law is the bunch of activities of UN administration subdivisions in the field of environmental protection, since energy is one of its main polluters, and therefore international environmental standards will have significant consequences for the work of this sector. In addition, during the development of the UN structure, a separate subsidiary for activities in the energy sector has not been created. At this time, international organizations in the UN system exercise influence on international energy law through activities in the areas of international trade and investment (UNCTAD), environmental protection (UNESCO, UNEP, Commission on Sustainable Development), as well as specialized agencies like the World Bank and the International Monetary Fund, apart from it (Fig. 5).

In hydropower sector, several international organizations could be singled out as the main ones, with the joint efforts of which a technical set of rules is published, which collectively constitutes the Methodology for assessing the compliance of hydropower projects with sustainable development criteria (HSAP). The HSAP provides a world common language on however these measures could be self-addressed in the slightest degree stages of the project

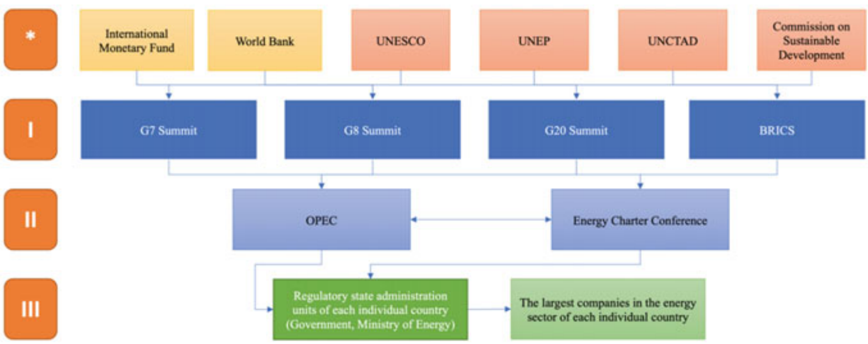

Fig. 5 Schematic structure of global governance in the world energy market (*Source* Compiled by authors according to [United Nations Educational, Scientific and Cultural Organization 2020]. *Note* I, II, III—levels of hierarchical importance of organizations in the structure; *—supra-departmental level that has an indirect impact)

life cycle: designing, preparation, implementation and operation. The assessment protocol was developed on the basis of a 30-month cross-sectoral interaction between 2007 and 2010, as well as an analysis of previous IHA sustainable development instruments (International Hydropower Association 2020e), recommendations of the World Commission on Dams (The World Commission on Dams 2020), Equator Principles (The Equator Principles 2020), Security Policy (World Bank 2020) and the Performance Standards (International Finance Corporation 2020).

Throughout this time, parties concerned forum conjointly reviewed, distended and developed an agreement on what a real sustainable project ought to appear as if. This forum was attended by representatives of various non-governmental organizations, such as environmental (like WWF and The Nature Conservancy), social (Oxfam and Transparency International), development banks (World Bank etc.), governments (of such countries as China, Zambia, Germany, Iceland, Norway) and therefore the hydropower sector (International Hydropower Association 2020e).

In 2009, the HSAP project was released and tested in 16 countries on six continents and has further refined. The final version was released in 2010. In parallel, a Governing Board was formed to manage the advancement of HSAP using the same multistakeholder approach that was used to create it (Fig. 6).

In 2018, HSAP was swollen to comprehend best practices in global climate change alleviation and tension, and got an update once more with new steerage, aimed at indigenous peoples in 2020 (International Hydropower Association 2020c).

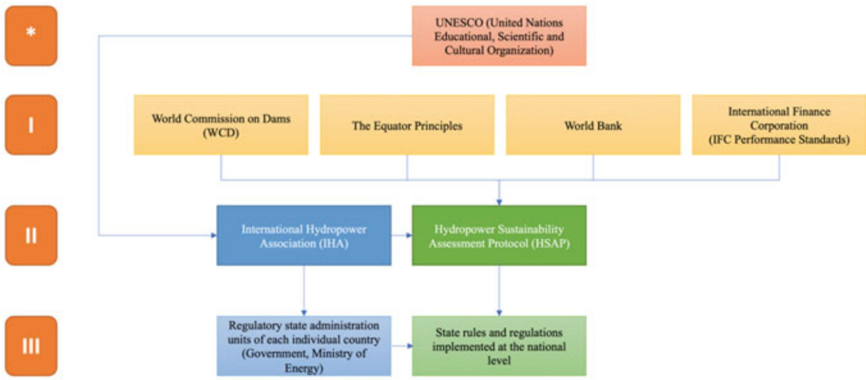

Fig. 6 Schematic structure of global governance in the world hydropower (*Source* Compiled by authors according to [United Nations Educational, Scientific and Cultural Organization 2020]. *Note* I, II, III—levels of hierarchical importance of organizations in the structure; *—supra-departmental level that has an indirect impact)

3.3 Market Conditions

The global hydropower market forms a market chain with a huge number of markets whose products include or use energy and water resources.

It is a single product market that is a part of the global fuel and energy market and the main renewable energy market; raw material; has a limited assortment loop without an extensive system of price couplings; in relation to the markets of wind energy, solar energy, bioenergy, and geothermal energy has a high price conductivity, and in relation to other markets—a low degree of passability of the price impulse; a market with a limited area of influence on other markets; negative in relation to other energy markets, especially—oil, gas, nuclear energy and coal industry (Andronova and Kolbikova 2016).

Below are datasets (Table 3) for the main energy sectors using renewable energy sources (RES). According to the data of the intergovernmental organization, which is the main platform for international cooperation in the field of sustainable development and use of renewable energy sources, the International Renewable Energy Agency (IRENA), the cheapest in terms of the global average cost of electricity is the hydropower sector – the cost of production is USD 0.047/KWH. The most expensive sector in terms of this indicator is the concentrated solar energy sector – USD 0.185/ KWH.

The price difference is understandable. Hydropower is one of the most cost-effective methods of generating electricity and it is often the preferred method when technically feasible. For example, in Norway about 99% of electricity is generated by hydropower facilities (International Renewable Energy Agency 2020). At the same time, in terms of specific emissions of CO_2, SO_2 and NO_2, hydropower also remains the leader in the renewable energy market.

As a result, one could say that the most successful choice, subject to the technical feasibility and the need for implementation, is the hydropower sector. Thus, in the presence of technically and economically exploitable hydropotential, this sector shows maximum flexibility and production capacity with minimum negative impact on the environment and costs.

4 Conclusions

There are currently trends characteristic of the world energy industry and the world economy as a whole in the development and functioning of hydropower in the world and in individual countries.

First of all, in accordance with the Concept of sustainable development of mankind, social and environmental requirements for the design and construction of hydropower plants are increasing. These factors were most acutely manifested in developed countries with limited opportunities for the construction of traditional hydroelectric power plants. For example, in the United States, the rise in land prices became one of the reasons for the transition to the construction of small hydroelectric power plants and pumped storage power plants, and the need to restore the conditions for the reproduction of salmon

Table 3 Conjuncture in commodity groups of renewable energy sources market

Energy source	*Specific CO_2 emission (g/KWH)*	*Specific SO_2 emission (g/KWH)*	*Specific NO_2 emission (g/KWH)*	*Features of the impact on the environment*	*Global weighted-average cost of electricity (USD/KWH) 2018*
Bioenergy	21.00	0.11	1.42	An increase in the load on the agricultural sector, and as a result, a decrease in food production; rise in prices for food raw materials; deforestation	0.062
Geothermal	79.00	0.02	0.28	Increased seismicity in the areas where the stations are installed; subsidence of the earth's surface; when located in a mountainous area—the potential for landslides; thermal pollution and an increase in the concentration of salts and other chemical elements due to the discharge of condensate into the water	0.072
Hydro	7.60	0.016	0.005	Flooding of agricultural lands and settlements; violation of the water balance; impact on flora and fauna; obstruction of the free movement of fish	0.047

(continued)

Table 3 (continued)

Energy source	*Specific CO_2 emission (g/KWH)*	*Specific SO_2 emission (g/KWH)*	*Specific NO_2 emission (g/KWH)*	*Features of the impact on the environment*	*Global weighted-average cost of electricity (USD/KWH) 2018*
Solar photovoltaics	135.00	0.27	0.24	Alienation of large land areas, their possible degradation; darkening large areas with solar concentrators; change in heat balance; danger of environmental pollution environments with toxic substances—sulfuric acid, lead and cadmium (in production); transmission of energy from space SES to Earth in the form of microwave radiation, which is dangerous for living organisms and humans	0.085
Concentrating solar power	32.00	0.2	0.1		0.185
Wind (avg.)	8.00	0.06	0.04	Alienation of large land areas; interference with air traffic and radio and television broadcasting; the prospect of warming in the WPP regions	0.092

Source Compiled and calculated by authors according to (International Renewable Energy Agency 2018a). *Note* Data provided by the end of 2018 fish in some cases led to the question of reconstruction and even termination of the operation of some hydroelectric power plants (Lagerev et al. 2004).

One of the global trends in hydropower is the increasing role of the global financial market in hydropower investment, especially in developing countries. Along with government investments in the construction of hydroelectric power plants in these countries, the volumes of loans from the World and regional (American and Asian) development banks, as well as private banks and investors, are growing.

An important factor in globalization in the hydropower industry is also the functioning of the world market for generating and electrical equipment. In many cases, HPPs being built in developing countries are equipped with export equipment. For example, the generators of large hydropower plants Itaipu are made in Germany, and Guri—in Japan. The largest hydroelectric power station in China, Three Gorges, is equipped with equipment from the Brazilian and French sides.

International cooperation is developing in the joint construction of hydroelectric power plants. In particular, one of the fairly significant events supporting this is the signing of an agreement on cooperation in the construction of a pumped storage power plant in Russia between PJSC RusHydro and the Chinese energy company PowerChina in June 2019 (RusHydro PJSC press center 2019). In addition to joint cooperation on the construction and development of pumped storage power plants, the subject of the agreement was also a project of cooperation in the field of design and engineering in third countries. At the moment, RusHydro, which supports the updated policy of partners from the People's Republic of China regarding the development of pumped storage power plants to increase the flexibility and reliability of the energy system as a whole, is working out measures to support these investment projects, making them economically feasible for the formation of future cashflows (The Government of the Russian Federation 2017). This agreement allows for a comprehensive exchange of experience between specialists from Russia and China with the prospect of long-term and productive cooperation.

And finally, among the most important global trends that seriously affect the development of hydropower at the present stage, the liberalization of the electric power industry being carried out in many countries of the world, accompanied by the restructuring of administrative units and a change in the mechanisms for managing power supply systems during the transition to market relations. The impact of this process on hydropower construction is assessed ambiguously. On the one hand, market conditions expand the opportunities for attracting private and bank capital, primarily for the construction of small and medium-sized HPPs (Chernyaev, M.V. 2020). But on the other hand, large hydropower projects, which are expensive, with long construction periods and payback periods, are not attractive for investments, and their implementation turns out to be practically impossible without investment support from the state (creation of consortia with the participation of state capital, tax cuts, as well as customs duties on imported hydropower equipment, construction equipment, etc.).

Thus, in current conditions of the global transition to Industry 4.0, the large-scale development of hydropower in individual countries should remain an element of state energy policy.

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Sustainable Development and Industry 4.0 Determinants in Communication Strategies in Fuel and Energy Complex

Elena A. Ponomareva, Elena A. Nozdrenko, and Alina G. Mysakova

1 Introduction

The enterprises of the fuel and energy complex are the most important component of the world economy and in many respects influence the level of global and national economic development. Thanks to fuel and energy industry, employment is ensured, and cities and entire countries are growing steadily. Energy companies have a positive impact both on the country's economy and on the development of international trade as a whole. Moreover, the resources and products of enterprises can serve as powerful geopolitical tool and influence relations between countries. Due to the uneven distribution of fuel and energy resources on the planet, energy-exporting countries have political leverage over pressure on importing countries. As a result of this, the development of its own fuel and energy complex is the most important policy task of any state.

At the same time, the specifics of the activities of energy companies are associated with enormous damage to the environment. The main sources of pollution in the process of exploration and subsequent production of hydrocarbons: accidental emissions of solutions, accidental emissions of the raw material itself, unauthorized discharge of formation water and sludge,

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accidental small-scale leaks or agitation of bottom sediments during well drilling.

Water and the atmosphere are also affected by the activities of fuel and energy companies. The main sources of atmospheric pollution are thermal power plants, and the thermal ash removal systems of thermal power plants pollute water bodies and groundwater. Pollutants are discharged into wastewater from water bodies, of which predominantly for the power industry are suspended solids, oil products, chlorides, sulfates, salts of heavy metals, specific substances (hydrogen sulfide, caprolactam, formaldehyde).

All these phenomena negatively affect the reputation of fuel and energy companies and public perception of these companies, their reputation in the society. However, whatever the specifics of the activities of energy companies are they make a huge contribution to the development of society and it is simply impossible to abandon fossil fuels.

Because of issue linkage, fuel and energy companies actively improve public relations by stressing the positive impacts they have for economic and social developments. Sustainable development program can be an invaluable lens through which to evaluate the industry and anticipate future regulatory action – giving the opportunity to manage their risks, time to adapt, and ability to maintain long-term value growth.

Today the "Sustainable Development Agenda" comprises a platform of seventeen separate sustainable development goals most of which are used in the communication activity by the fuel and energy companies.

The implementation of communication strategies in FEC based on the concept of green growth and sustainable development is becoming a significant factor in the international competitiveness of fuel and energy companies in the global 4.0 economy.

2 Methodology

This study contains an analysis of the information and communication activities of the leading companies in the global fuel and energy industry in order to identify effective communication strategies that provide companies with competitive advantages and sustainable development in the context of globalization and 4.0 economy trends.

The theoretical basis of the research is the modern system of economic, cultural, and sociological knowledge that underpins the basic requirements for the scientific theories, essence, structure and methods for applying various analytical tools in the field of communications. Research methods obtain the fundamental principles of communication theory. During the research, the scientific works of domestic and foreign scientists on various aspects of communications, public and governmental relations as far as economic analysis, consumer culture and sustainable development strategies were used. To lay the empirical base of the study, the researchers used the data officially published on fuel and energy industry web sites and portals, including expert evaluation and statistics.

In the research of the FEC effectiveness of communication strategies issue, methods of logical and statistical analysis, the method of explicating the concept of "green economy", as well as the synergistic principle of studying communication strategies were used.

3 Results

In the modern world the fuel and energy complex focuses on ensuring the country's energy security. The development signs of its industries are indicators of the economy, social and foreign policy. At the same time, the resource base and the marketable product are decoded as a powerful geopolitical weapon and a factor of influence on the foreign policy of states. Consequently, the development of its own fuel and energy complex and its reputation structure belong to the strategic priorities of any state.

Global community is actively promoting the rejection of the traditional energy sources usage, the transition to cleaner sources. Governments are adopting high environmental standards that directly influence FEC. The activities of enterprises are associated with enormous damage to the environment and a huge risk to the people's lives working on platforms, mines and factories for the production of energy and raw materials. These facts almost always cause a considerable attention from the media.

All these events negatively affect the reputation of the fuel and energy companies and their public perception. Eco-activists, including the Swedish schoolgirl Greta Thunberg, who became famous around the world for her climate strikes, are actively urging businessmen and politicians to abandon the use of coal, oil and gas in favor of renewable energy sources.

There is a number of modern publications and studies devoted to the "green economy" Due to Dan Brockington & Stefano Ponte (2015) green economy concept promises to provide a concrete roadmap to the implementation of sustainable development while delivering significant social and economic benefits and reduced environmental risks. However, the concept of a green economy is still being debated and the emerging discourse has yet to be fully interpreted within the industrial, institutional and socio-economic realities of many countries, including particularly emerging and developing nations.[1]

Green economy concept really influenced on actual economic activity.[2] This analysis of the related idea of 'green growth' focusses upon the articulation of

[1] Brockington D. and Ponte S. (2015), "The Green Economy in the global South: experiences, redistributions and resistance", Third World Quarterly, 36:12, 2197–2206, DOI: https://doi.org/10.1080/01436597.2015.1086639.

[2] Bracking S. (2015), "Performativity in the Green Economy: how far does climate finance create a fictive economy?", Third World Quarterly, 36:12, 2337–2357, DOI: https://doi.org/10.1080/01436597.2015.1086263.

these discourses within key international economic and environmental institutions and evaluates whether this implies the beginning of an institutional transformation towards an ecologically sustainable world economy 4.0.[3]

Green economy concept refers to critical appraisal of the logics and mechanisms of governance and transition that see the green economy as a key mechanism for economic, social and environmental change.[4]

Based on global trends and social processes, the transition of FEC to "green economy" is clearly defined. The concept of nature management and environmental safety or necessity of "green" growth is actively discussed in all countries and at all levels. The United Nations, the Global Green Growth Institute (GGGI) and many other organizations are actively promoting the idea of a green economy. Different states define priorities for its development in different ways: developed countries have competition and jobs at the top; emerging countries are concerned about sustainable development, tackling poverty, justice and civil rights; the BRICS group (Brazil, Russia, India, China, South Africa)—votes for resource efficiency.[5]

Green energy transformation reflects the mainstream development and modernization in the Russian energy sector which implies the use of energy-efficient technologies, environmentally friendly and low-carbon energy sources. According to the "Russian Energy Strategy" up to 2030, companies need to ensure the energy security of the state by developing alternative energy. This project highlights the communication strategies effectiveness issue in the process of promoting and competitive positioning of the "green economy". Today PR, advertising, GR and other communication technologies are the most important functions of FEC's energy management and energy marketing.

Considering the above, information and communication strategies acquire special significance among the factors of the FEC sustainable development in 4.0. The PR specialists' purpose is to create a consumers' positive image among about fuel and energy companies, and the communications department purpose is to promptly report and provide the necessary information to the media in order to avoid negative news about the company's activities, which can significantly worsen its image. Indeed, if *BP* specialists paid more

[3] Ferguson P. (2015), "The green economy agenda: business as usual or transformational discourse?", Environmental Politics, 24:1, 17–37, DOI: https://doi.org/10.1080/09644016.2014.919748.

[4] Caprotti F. and Bailey I. (2014), "Making sense of the green economy", Geografiska Annaler: Series B, Human Geography, 96:3, 195–200, DOI: https://doi.org/10.1111/geob.12045.

[5] Porfiriev B.N. (2013), "Green Economy: Realities, Prospects and Limits of Growth" / Carnegie Moscow Center. April. pp. 33.

attention to communication activity after the Deepwater Horizon accident, the reputational loss would not be so great.[6]

Thus, companies that have an ambiguous effect on environment, working conditions, living standard of people who live nearby the FEC enterprises, etc. should pay particular attention to the formation of consumers' awareness of the society's energy security. The competent information and communication policy appeal to be the most important tool in achieving this goal.

Currently it is stated, the high quality, low price or wide distribution network are no longer the key arguments to ensure commercial success of a company. Even reputation becomes the most important factor in the consumer loyalty to the company. Reputational indicators guarantee both the success of the company and the cause of its failure.

Communication strategy we define as planned actions to achieve desired results determined by sustainable development and 4.0 factors. Fuel and energy companies use communication activity in order to counteract negative consumer opinion. Since today's consumers perceive that they are paying higher prices for gasoline, they want the sense of receiving more value for their money. Many consumers now choose their gasoline based on brand benefits rather than price. Energy companies are using corporate advertising to promote the quality of their products and the consumption experience. Energy companies are also using advertising to address the consumer's concern about environmental issues. Data in this study include national public opinion data along with financial information and advertising expenditures of the top energy companies.[7]

Company's reputation determinates the investors' activity, therefore it is very important to cooperate with the company's investors which provides the IR (or Investor Relations). Prompt notification to investors contributes to the flow of funds necessary for the companies' activities. In addition to the complex of external communications, companies have a system of internal communications system that allows to deliver and exchange information between employees. It's not appropriate to neglect the proper internal communications at FEC enterprises. Practice shows that there are cases when employees revealed their enterprise secrets to journalists, not realizing that the information they own is restricted to internal use. Such actions from uninformed employees can entail serious reputational consequences.

Modern enterprises are switching their production to automatization, a virtual assessment of the progress made. Various technological solutions are widely used in the development, production, processing, and transportation of energy resources at the fuel and energy complex. Existing technologies

[6] Shogren E. (2011), "BP: A Textbook Example Of How Not To Handle PR" available at: https://www.npr.org/2011/04/21/135575238/bp-a-textbook-example-of-how-not-to-handle-pr (accessed 31 October 2020).

[7] Smith K.T., Smith L.M., Dunbar S. (2014), "Using corporate advertising to improve public perception of energy companies", Journal of Strategic Marketing, 22:4, 347–356, DOI: https://doi.org/10.1080/0965254X.2013.876080.

are being improved every year, while more and more new solutions are being developed. Thus, marketing and advertising specialists are able to see Internet users in the context of thousands of segments, to aggregate them with different logic in order to determine the most effective combinations for the brand. There are several groups of technologies used in the information and communication activities of FEC enterprises, depending on the methods and purposes of communication.

Artificial intelligence (AI) is based on several key technologies such as machine learning, natural language processing, rule-based expert systems, neural networks, deep learning, physical robots, and robotic process automation (Davenport 2018). Using these tools, AI provides the means to "correctly interpret external data, learn from it, and demonstrate agile adaptation" (Davenport 2018). Another way of describing AI depends not on the underlying technology, but on its marketing and business applications, such as business process automation, data analysis. Technologies related to machine learning (ML), robotic process automation (RPA), neural networks, bots, the broader field of artificial intelligence (AI) and natural language processing (NLP) are known as cognitive technologies (Bestari et al. 2020) (Table 1).

The above classified tools can be divided in two groups of technologies used in the enterprises' communication activities:

(1) technologies that analyze the communication channels effectiveness of enterprises with their target audience (consumers, public, government agencies, stakeholders, etc.);

Table 1 Modern technologies used in FEC's information and communication Activities with AI[8]

Goals	*AI tools*
Analysis of the communication channels effectiveness with the target audience	Mass media monitoring, social networks, information audit
Influence on the opinion of the target audience	Writing texts, preparation of analytic reports, conducting online conferences, application design, Internet platforms (youtube) and social networks (twitter, facebook), creating and posting in Internet of audio / video content (advertising, podcasts)
Attracting new and increasing loyalty of current customers	Automated data analysis, micro-targeting, interactive email marketing campaigns, content marketing

[8] Desinged by authors based on Ponomareva E.A. Global communication policy of fuel and energy companies: Moscow State Institute of International Relations (University), School of Government and International Affairs, Department of Management, marketing and Foreign Economic Activity, 2020.

(2) technologies that allow directly influencing opinion.

Artificial intelligence allows to analysis communication channels and its influence effectiveness on the target audiences. Its capabilities allow to analyze published articles in the media for positive, negative and neutral references. Based on the results of such monitoring, special attention should be paid to work with negative issues.

In Russia there is a number of such media monitoring systems such as Medialogy, Youscan, Brand Analytics. However, the limiting fact of the usage is quite Russian-speaking content. Currently, some international systems are represented in Russia such as Mediatoolkit,[9] Mediascouting[10] and others. Having access to one of the monitoring systems, it's possible to get a report on mentions of the relevant object in the media for a certain period of time. For example, a part of the report on monitoring the mentions of ExxonMobil in the media can be provided (Fig. 1).

According to the report, the largest number of the company's positive media mentions during five years were made in Forbes. Among the Russian media, RIA Novosti and TASS (news agency) distinguished themselves in positive references to the company. Due to this report, it can be concluded that ExxonMobil has smart and positive relationship with Forbes journalists. At the same time, the company should pay more attention to cooperation with journalists from Russia Today, Vesti, Vedomosti, as these agencies have minority of positive references about such company in contrast with agencies mentioned

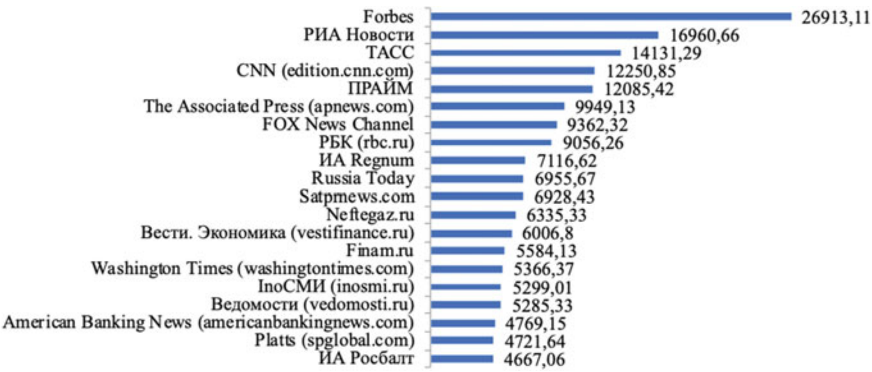


Fig. 1 Most active media outlets in positive mentions of ExxonMobil from 2015 to 2020[11]

[9] available at: https://www.mediatoolkit.com/pricing (accessed 3 February 2020).

[10] available at: https://datascouting.com/media-monitoring-software/?gclid=EAIaIQobChMI6aHClfOL6QIVhKoYCh2xnwVeEAAYAiAAEgKtLfD_BwE (accessed 3 February 2020).

[11] "Compiled on the basis of reports of the monitoring and analysis system of media and social networks "Medialogia" https://www.mlg.ru (accessed 28 April 2020).

above. Having such monitoring systems, it's possible to identify weaknesses in communication activities of any company and significantly improve its effectiveness.

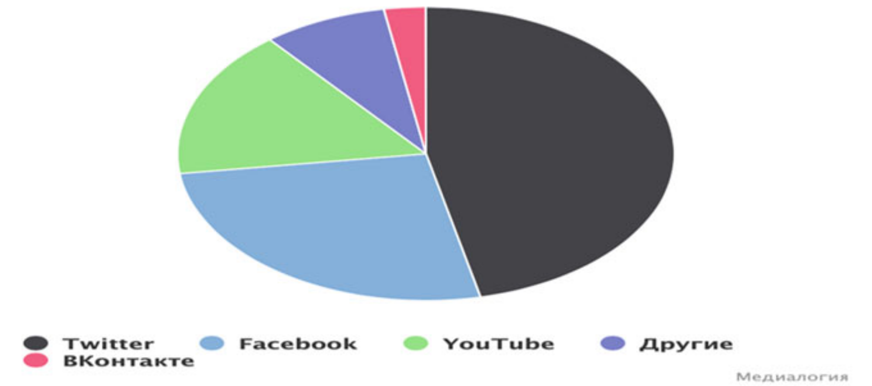
Due to changes in composition and consumption habits of the "digitalized" audience the use of various online platforms for posting articles and videos is also important in the communication activity in FEC. Representatives of the generation "X" consumers have long been replaced in active consumption by representatives of the "Y" generation, who, in their turn, are inferior to the position of active consumers to the "Z" generation. The matured Z-buyers are moving into the status of active consumers, which fundamentally changes the means, forms and methods of communication (transition to simpler messages, more use of visual context and communication in social networks) and, consequently, the system and methodology of media research is changing.

Today young people are the most important audiences for FEC companies, because in the nearest future they become employees or consumers. They grew up in the digital revolution era, they are easily managed with various technological innovations and gadgets. Consequently, many fuel and energy companies use communication channels which are popular among young people. Particularly, "facebook", "twitter" and "youtube". For example, the figure below shows that "Twitter" has the largest distribution coverage by the number of subscribers (more than a billion people) in which messages about ExxonMobil are published (Fig. 2).

Other energy companies have similar statistics, most of them have their own pages on the social networks "Twitter" and "Facebook", where they publish important news for that. In addition, Youtube has gained huge popularity among fuel and energy companies, which provides an opportunity to upload videos, instantly track view statistics, evaluate the effectiveness of this communication tool and, in general, influence the perception of the public opinion. Thus, Shell publishes various videos on its Youtube channel describing the benefits of the renewable energy sources, which improves the company's image in the young's minds, and also influence the public's perception of environmental pollution problems.

Companies develop their own mobile applications to attract children and youth attention to the FEC's activities. For example, BP has developed its own app, which is called "BP Ultimate Rally Challenge".[12] The game received favorable reviews from critics (8.1 out of 10) and attracted more than 20 thousand users from all over the world. In addition, most large oil and gas

[12] available at: https://jayisgames.com/review/bp-ultimate-rally.php (accessed 4 February 2020).



Площадка	Аудитория
Twitter	1 158 790 420
Facebook	657 534 440
YouTube	407 248 217
ВКонтакте	67 435 396
Другие	202 076 898

Fig. 2 Outreach by the number of blogs' subscribers in which messages about ExxonMobil are published[13]

companies (Royal Dutch Shell, ExxonMobil) have their own apps, which publish important news for consumers, various practical information, etc.[14]

Modern technological solutions are actively used in the FEC's marketing communications. Artificial intelligence systems allow us to analyze a huge amount of data about target audiences, study their requests and needs, monitoring advertising campaigns as a part of energy marketing. These opportunities optimize the resource base usage of the company's marketing and advertising activities as a whole (micro-targeting, interactive marketing e-mail campaigns).

The efficiency of the FEC information and communication activities in new versions is beyond doubt. The 2020 coronavirus pandemic crisis has given a huge boost to companies in their development. Under these conditions, companies hold their events (including press conferences) online. Meanwhile, the outreach is often much even greater than in the traditional way. Today, there are various platforms that allow this kind of communication to be carried

[13] Compiled by authors based on the reports from the media monitoring and analysis system and social networks by Medialogia, available at: https://www.mlg.ru (accessed 4 February 2020).

[14] available at: https://play.google.com/store/search?q=Royal%20Dutch%20shell&c=apps&hl=en_US (accessed 4 February 2020).

out online (Zoom, Skype, Mind, etc.). Companies that have successfully integrated these platforms into their activities will continue to hold public events online in order to save money and time.

Today, fuel and energy enterprises have a large number of opportunities to interact with consumers, shareholders, government institutions. Building an effective information and communication strategy is a priority for FEC companies in realizing competitive positioning. Effective communication strategies allow to monitor the strengths and weaknesses of the communication channels in use and develop a long-term action plan. According to the Gazprom PR department manager, there was no need to build relationships with potential customers before, as the supply on the market run its own order. Now, in the customer's market environment, there is a need to sell the image of companies in order to stand out from the competitors. Thus, the positive or negative perception of the company in the public's mind depends on the communication specialists' activity.[15]

In our opinion, fuel and energy companies provide their information and communication activities in the priority strategic field of environmental PR; positioning the company in the development of alternative energy; positioning the company as a socially responsible business; satisfaction of public demand.

Let's consider the main directions of large energy companies' information and communication activities and tools used within these strategies. For example, "Gazprom" forms its image on significant importance for the development of the country's economy. It provides nation image both within the country and abroad, leading to satisfy public demand. The company has launched a long-term advertising campaign in 2003 entitled "Gazprom is a national treasure", a message that had been broadcasting in the media for over 10 years. The Federal Antimonopoly Service reached the decision to stop using the title "national treasure" in 2016, regarding themselves under the Article 5 of the law "on advertising" (false advertising). "Gazprom" removed advertisement with this slogan, however, using it for more than 10 years has contributed to forming image that has a significant role in development of the Russian economy. Such image has rooted into the minds of Russian and foreign people.

The success and recognition of "Gazprom" abroad is also associated with the steps taken by the company in the external market. Gazprom pays particular attention to the corporate social responsibility policy, in which the company organizes and holds various events aimed at the children and youth's development ("Gazprom for Children" is a program aimed at Russian citizens, "Football for Friendship" is an international program). These programs are covered in both national and foreign media as an example of a socially responsible enterprise in the fuel and energy complex.

[15] available at: http://www.advlab.ru/articles/article301.htm (accessed 15 January 2020).

It is known that Gazprom is an official partner of the UEFA Champions League, as well as a sponsor of various European football clubs such as British Chelsea and Germany's Schalke 04. Taking into account the special passion of the British and Germans for football, the football teams' sponsorship has become Gazprom's excellent PR move. The headline of the article "Gazprom and Germany are connected with each other due to football and Schalke 04" is exactly that positive result that the company would count on from such cooperation. Of course, there are many pitfalls in the political relations of the two countries, many articles in the foreign media have been written about the fact that Russia is thus increasing Germany's dependence on its energy resources.[16] Since then, brand recognition abroad has significantly increased, fulfilling the purpose of properly positioning "Gazprom" and strengthening its reputation as a global energy company implementing global projects.

The communication strategy of the Norwegian company *Equinor* has its own specifics. The company places the greatest emphasis on technology, environmental protection and the development of alternative energy sources. Equinor positions itself as the world's most CO2 efficient oil and gas company. In addition, according to regularly published reports and press conferences the company heavily invests in the alternative energy sources development. Like many other oil and gas companies, Equinor cares about the future of young people and funds Morgendagens helter (Tomorrow's heroes) talent program.[17] Moreover, under this program, a Norwegian company is a sponsor of various awards, the size of which varies from 83,000 to 166,000 USD.[18] However, the most remarkable PR move made by the management is the change of the company's name from Statoil to Equinor in 2018. The general management of the enterprise decided to move away from the company's exclusively oil and gas image as in the Norwegian language "Statoil" means a state oil company. Now the company has officially secured a new name reflecting its attitude towards the population, energy, environment and the future of the country (Equinor = equality, equilibrium in Norway).[19]

British-Dutch oil and gas company *Royal Dutch Shell* realized the need to make qualitative changes in its activities in 1999, based on the movement to protect the environment. The main tool for achieving this goal was an information and communication strategy, which created the oil and gas company's image concerned with the problems of climate change, environmental protection and the struggle for labor rights. The company organized a large-scale

[16] available at: http://bundesligafanatic.com/20140312/gazprom-schalke-metonym-for-german-dependence-russian-resouces/ (accessed 20 January 2020).

[17] available at: https://www.equinor.com/en/about-us/heroes-of-tomorrow.html (accessed 20 January 2020).

[18] available at: https://www.nrk.no/kultur/millionen-som-deler-musikk-noreg-1.8399303 (accessed 22 January 2020).

[19] available at: https://www.equinor.com/en/about-us/about-our-name-change.html (accessed 4 March 2020).

environmental PR campaign in 2018, targeting young people. Using modern communications, the company's specialists attracted well-known performers to participate in a video about solar installations, hydrogen transport, etc. One of these videos reached over 800 million views on the Youtube platform, which is an indicator of the absolute success of the PR campaign.

Despite the fact that Royal Dutch Shell is often criticized in the media for failing to keep the announced promises (non-observance of human rights in Nigeria,[20] disregard for the rights of local residents while drilling on the Arctic shelf,[21] etc.), the company is actively engaged in the research and development of alternative energy sources as well as social programs for their workers.[22]

The French company *Total*, like its *British-Dutch* competitor, is seeking to move away from the traditional model of an oil and gas company towards an energy company that develops a full range of different energy sources. The company spends more than $500 million annually on the development of alternative energy sources.[23] The company shows its investors and the public how it cares about the environment, actively involved in environmental PR. For example, most of the news on the site is devoted to actions aimed at protecting the environment, in addition, the site publishes an annual report on the progress made by Integrating Climate into Our Strategy.[24]

Thus, each company adheres to such a communication strategy that allows it to achieve its own positioning goals. However, with increasing corporate and social responsibility in the world, it is clear that this concept heads of the information and communication strategies for the majority of oil and gas enterprises which take a combination of various marketing and PR tools as the key concept to achieve goals. The FEC tendency to carry out various programs aimed at young people is clearly traced under this strategy. No wonder, some of these young people will make up the workforce of these companies in the future, so there is a need to create a positive image of the fuel and energy enterprises' activities for youth since childhood, using popular communication tools.

4 Conclusion

The FEC companies, due to their specific activities, ambiguously affect such aspects as the nature environment, working conditions and standards of living

[20] available at: http://priceofoil.org/2010/11/10/shells-nigerian-pr-strategy-exposed/ (accessed 23 January 2020).

[21] available at: https://www.ecowatch.com/air-pollution-cardiac-arrests-2644941669.html (accessed 23 January 2020).

[22] available at: https://www.shell.com/sustainability/our-approach/commitments-policies-and-standards.html (accessed 23 January 2020).

[23] available at: https://www.sciencedirect.com/science/article/pii/S2211467X19300574 (accessed 4 March 2020).

[24] available at: https://www.total.com/sites/default/files/atoms/files/total_rapport_climat_2019_en.pdf (accessed 4 March 2020).

should pay more attention on forming real consumers' expectations and behavior about the energy security in the society.

The research proves that today such advantages as high quality, low price, wide distribution network are no longer the key aspects in ensuring the commercial success of a company in 4.0 ecomony. Today, sustainable development in the fuel and energy sector requires new approaches to production based on artificial intelligence models and green concept reputation that becomes the most important factor in the formation of company's customer loyalty, can guarantee the company's success.

In the era of technology development, companies have received a number of new communication tools such as media and social media monitoring, data analysis, and micro-targeting. Despite the fact that such tools are still at the stage of development in FEC, they will undoubtedly be used everywhere in the future.

The most important tool for achieving this goal is the development of a competent policy in information and communication, that is a key tool for building reputation, that helps to create cooperation between companies and target audiences.

Companies are to pay attention either to external or internal communication field in order to achieve set goals which provides effective information and communication policy. The main purpose here is to clearly define the target audience, communication methods and suitable tools.

Today, there are five main areas of fuel and energy companies' communication activities that can be distinguished: environmental PR, positioning of alternative types of energy and the company as a socially responsible business, satisfaction of public demand, anti-crisis management, and corporate communications.[25]

PR and GR are the most important tools for the communication strategy of any company, but they are especially important for FEC companies which need to work to maintain a good reputation, inform the media promptly, and have smart and positive relationships with government authorities through relevant events with their participation, as well as through lobbying.

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The Energy Sector Amid an Industry 4.0: Issues of Information Support Transformation

Marina D. Simonova, Irina P. Mamiy, and Mikhail A. Ivashchenko

1 Introduction

One of the leading and priority areas for the development of the Russian economy is the modernization and improvement of the country's energy sector, which constitutes 25% of GDP, about 40% of the federal budget (Report 2020) and is a powerful tool for the implementation of domestic and foreign policy of the state. The Energy Strategy of Russia for the period up to 2035 determines that "the goal of the development of the energy sector of the Russian Federation is, on the one hand, the maximum assistance to the socio-economic development of the country, and on the other hand, the strengthening and preservation of the position of the Russian Federation in the world energy sector" (Energy 2020).

To make informed decisions in this area, reliable information support is required. Information support includes a set of data banks, means, methods and technologies for collecting and processing, accumulating and issuing information. It is the fourth industrial revolution and the introduction of Industry 4.0 standards that will contribute to a expand full-scale use of digital technologies, operational control and the use of cloud storage systems and remote control of production processes, as well as decision-making in real time. A

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critical part of the change process is the global energy sector, in which new approaches to the economy require the development of new methodology for collecting and processing data to provide users with complete, consistent and reliable information.

The current state of the Russian economy requires a revision of the fundamental approaches to assessments and strategic directions for the development of the energy sector. The aim of the work is to analyze the currently existing statistical tools and methodology, at different levels of information support, which are used to collect data in the energy sector of the economy, to form new information flows and an assessment of possible directions for the development and improvement of the system of indicators for energy statistics by constructing accounts of energy resources in value terms within the framework of the System of Natural Environmental Accounting (NEA) and satellite energy accounts within the framework of the System of National Accounts (SNA).

In order to improve the system of energy statistics indicators, the authors considered the problems and ways of expanding the information support of indicators at different levels and ways to overcome these problems in the context of the new industrial revolution and the development of industry 4.0.

In the course of the study, the energy sector of the Russian economy was considered as the object of study, and the subject of the study was the sources and methodology for collecting and processing information on the performance of the energy sector of the Russian economy in accordance with international standards.

The new industrial revolution and the introduction of Industry 4.0 technologies is a new stage in the development of both the economy as a whole and the systems of statistical accounting and information analysis in the energy sector in particular. Currently, a digital analytical platform is being created in Russia—an integral tool for collecting and analyzing statistical information received by state bodies (Approved … 2019). The use of a unified approach to collecting not only primary statistical data, but also accounting and tax accounting data, will allow obtaining better analytical information on the state of movement of nonfinancial and financial resources, in the energy sector of the economy as well. “The platform will be one of the elements of the national data management system and a set of legal, methodological and information technology support tool, using which the continuous automation of the collection, storage, processing and dissemination of statistical information is carried out” (Approved … 2019).

One of the key features of Industry 4.0 is the widespread use of Big Data. Wide access to big data in the near future will allow for organizing and operating of primary information collection systems in the energy sector almost completely without human participation. New opportunities that the industrial revolution opens up in the field of technologies for collecting, storing and processing statistical information concerning the energy sector in general and, in particular, the problems of energy conservation, energy efficiency and "green energy" are reflected in the papers of academicians from different countries.

The most important task today is to analyze the available sources of statistical information on the operation of the energy sector and to find ways to modernize and transform approaches to collecting and processing energy data.

2 Methodology

The research tasks of analyzing and evaluating the tools that are used in the analysis of data related to the performance of the energy sector are solved by many specialists. M. Ambrose and M. James (2017) in their work discuss the problems that arise when collecting information on the consumption of energy resources in modern residential buildings. This paper explores the challenges of collecting information, with a particular focus on data used to assess the energy performance of residential buildings, including data on temperature, energy supply, and electricity and gas consumption.

E. Abelea et al. (2015) in their article discuss the collection of information for the purposes of energy monitoring and control of energy consumption of production machines using the capabilities provided by modern PLC (Power Line Communication) technologies. The energy consumption data collected in this way can be monitored on a connected HMI and stored on a common server for monitoring and further processing.

L. Paoli et al. (2018) explore the possibilities of using the concept of "useful energy" as a statistical tool for developing sustainable and energy efficiency policies. A new methodology based on a Bayesian approach has been developed, previously unpublished data on the average efficiency of the final consumption conversion device have been collected and the net energy balance has been calculated for the UK.

In his voluminous study "Energy Efficiency. Concepts and Computing" D. M. Martinez et al. (2019) consider the collection, analysis and use of information on the operation of both the energy sector of the economy as a whole and its various subsystems. The authors point to the need to reduce the energy intensity of the gross product as one of the priority tasks of economic development. Also the possibilities of "green energy" in the context of the concepts of Industry 4.0 are discussed.

Authors N. Brandt et al. (2017) propose a measurement system that takes into account the role of natural capital in measuring productivity. The system is applied to aggregated economic data from the OECD Productivity Database using natural capital data from the World Bank. It is shown that the direction of adjusting productivity growth depends on the rate of change in the amount of extracted natural capital relative to the rate of change in other resources.

The statistics and stock evolution of natural asset play a key role in analyzing the sustainability of economic growth. The publication of P.-A. Pionnier and S. Yamaguchi (2018). The article can be seen as a set of technical guidelines to support the compilation of mineral and energy accounts in accordance with the System of Environmental-Economic Accounting (SEEA) adopted in 2012.

Knudsen and a group of authors (2015) in their work present approaches to assess the amount of natural resources using modern methods in order to reduce uncertainty and errors. It is noted that the growth of natural resources reserves and the statistical methods used can differ significantly depending on the types of resources.

The existing gas pricing system in Russia is discussed by A. Makarov et al. (2019), and directions of its transformation are proposed. The authors note that "the methodology is based on the methods of system analysis using economic and mathematical optimization modeling of the fuel and energy complex and the economy. The current gas pricing system in the country is a constraining factor for the development of competition, increasing the efficiency of economic sectors, and modernizing the fuel and energy complex."

U. A. Plakitkin and L. S. Plakitkina in their article noted that "a global technological breakthrough, which allows to significantly increase labor productivity in the economy and reach a new level of its development, has recently been associated with the implementation of the Industry 4.0 program" (Plakitkin and Plakitkina 2017). The analysis of industrial revolutions and the corresponding world energy stages is carried out. "The experience of developing the Industry 4.0 program" in technologically developed countries is presented. It has been established that Germany, USA, Japan and China have already started implementing the Industry 4.0 program.

M. D. Simonova, V. E. Zakharov and I. P. Mamiy, in their paper (Simonova et al. 2019), analyze the consumption of renewable energy sources in the BRICS countries, taking into account structural differences in energy production and consumption. Using a comparative analysis, the authors study the current state and development prospects of the energy sector in the BRICS countries, identify the most promising areas for the development of the fuel and energy complex.

Currently, in accordance with the recommendations of the UN Statistics Division, several types of data sources are used for the purposes of information support of energy statistics (Energy 2016). First of all, there are administrative sources—reports from industrial enterprises reflecting the production, transformation and consumption of energy resources. Further, a very common source is questionnaires that are filled out by all enterprises—economic entities, i.e. not only by enterprises of the energy sector, but also by all other enterprises that consume energy resources. In Russia, such questionnaires are called "a form of federal statistical observation".

Simulation systems are of practical importance—the development of models for collecting and processing information, as well as direct measurements on site—in the conditions of Industry 4.0 these are systems of sensors and other measuring devices that can be connected in real time to systems for collecting statistical information. In addition, to improve the reliability of data, expert estimates and calculations are used based on indirect data or data from open sources.

FEB is considered as a document "containing interrelated indicators of the quantitative compliance of energy supplies to the territory of a constituent entity of the Russian Federation or a municipality and their consumption, establishing the distribution of energy resources between heat supply systems, consumers, consumer groups and allowing to determine the efficiency of energy resources use" (Federal … 2010).

3 Results and Discussion

FEB is a tool for making management decisions based on the derived indicators of energy consumption, for example, the energy intensity of GDP, consumption per capita, and the efficiency of their use.

The logical framework of the fuel and energy balance is shown in Table 1 (types of Fuel and Energy Resources—FER).

This balance sheet is consistent with the methodology for constructing fuel and energy balances used by international organizations, like the International Energy Agency and Eurostat (Guidelines … 2007), the Statistical Division of the UN Department of Economic and Social Affairs (International, IRES 2018) of the Energy Administration of the US Department of Energy (International … 2019).

Since the vertical columns of the balance table correspond to various types of fuel and energy resources (FER), the allocation of energy resources into groups with the required with the required specification allows to create both detailed (disaggregated) and collapsed (aggregated) balance tables. Horizontal lines of the balance table correspond to different movements or flows of fuel and energy resources in the course of economic activity (see Table 1).

The meaning of the word "balance" is that vertically for each column of the table, the arithmetic equality of indicators should be performed in accordance with the formula: "Conversion" + "Own consumption of the power industry"

Table 1 Logical framework of the fuel and energy balance

	FER1	*FER2*	…	*FERn*
1. Gross primary deliveries				
2. Statistical discrepancies				
3. Transformation				
4. Own consumption of the power industry				
5. Losses				
6. Final consumption, including:				
6.1 Energy consumption				
6.2 Non-energy consumption				

Source Mamiy (2011)

+ “Losses” + “Final consumption” − “Gross primary supplies” = Statistical discrepancies.

The official statistical information is source of input data for the formation of the FEB. The degree and nature of aggregation of primary information is established in accordance with the tasks in the formation of fuel and energy balance. Various types of energy resources are grouped on the basis of the All-Russian Classification of Products by Types of Economic Activity (OKPD).

The theoretical concept of fuel and energy balances was developed in the USSR, in the first half of the twentieth century. V. I. Veits et al. (1937) in their paper noted the need to create a unified fuel and energy balance “as a scientific basis for planning the development of a centralized energy economy.” They also proposed the first solution in the form of an energy balance table for the country’s economy.

The first complete energy balance was formed in 1958 L. A. Melentyev (1987) in his study “Development of the doctrine of energy balance” pointed out the need to develop a comprehensive energy balance for the entire country, taking into account all the processes of energy production and transformation.

Foreign researchers also developed initially enlarged and, over time, more detailed energy balances. The FEB was developed by individual countries and international organizations such as the International Energy Agency, Eurostat, the UN Statistical Commission and others.

By level of reporting within a country, energy statistics data for the case of Russia can be divided into four groups. The highest group in the hierarchy is the world energy balance (Fig. 1).

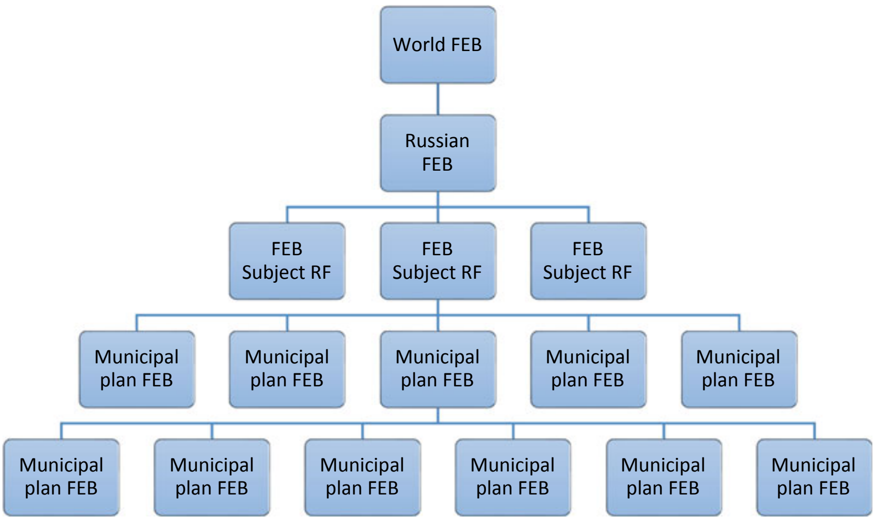

Fig. 1 Hierarchical structure of energy balances (*Source* Compiled from BP [2019])

In the practice of international organizations, the world energy balance is also compiled and applied, showing the movement of energy resources within the entire world economy (BP 2019). To compile the balances of countries and the aggregated world energy balance, special questionnaires are used, developed by experts from the International Energy Agency and Eurostat.[1]

In Table 2 the matrix of a unified FEB shows the production, conversion, losses and use of energy resources by economic activity.

The main contribution to the development of the theory of the Input–Output Tables (IOT) was done by V. V. Leontief et al. (1958). The concept reveals an economic and mathematical model that characterizes inter-industry relationships in the country's economy and allows measuring coordinated ties for the purpose of planning and forecasting processes. Subsequently, the development of the IOT became an essential part of the System of National Accounts (SNA).[2] Satellite accounts within the basic structures of the SNA are compiled for the purposes of analyzing the energy sector. The authors propose to compile functional accounts for solving problems of energy statistics, so that the basic statistical data can be rearranged to provide the required information (System … 2017).

At the same time, the integration of the energy balance in natural and monetary terms is of great interest further linked to the SNA, since for this, the flows of energy resources in value terms are much more important. That is carried out in the SNA using satellite accounts.

The following issues are relevant here: obtaining initial data; compilation of energy accounts in natural and value terms and the relationship between them; as well as linking energy statistics indicators to the international standard of the System of Natural and Economic Accounting (SEEA)[3] and building energy accounts. Within its framework, the energy account reflects information on the state of energy resources in physical and monetary terms, on energy consumption, as well as various energy-related operations of environmental interest.

In accordance with the international methodology, information on the state of energy resources, flows and assets is presented in two main types of accounts that record the physical flows of energy between the environment and the economy (measured in joules). Parallel accounts in value terms then register cash value associated with energy operations for energy products.[4] Since asset accounts are aimed at measuring the amount of mineral and energy resources

[1] http://government.ru/docs/all/64139/?page=17 (accessed 25 July 2020).

[2] https://unstats.un.org/unsd/nationalaccount/docs/sna2008russian.pdf (accessed 25 July 2020).

[3] https://unstats.un.org/unsd/envaccounting/seeaRev/CF_trans/SEEA_CF_Final_ru.pdf (accessed 25 July 2020).

[4] The planned development of methodological recommendations for constructing this account is entrusted to Rosstat, the Ministry of Natural Resources of the Russian Federation, Rosnedram and the Ministry of Energy of Russia by 2024. At the first stage, these

Table 2 Matrix of a unified fuel and energy balance

Indicator	*Coal*	*Crude oil*	*Petroleum product*	*Natural gas*	*Other fuels*	*Hydro and NWEI*	*NPP*	*Electric energyQ*	*Heat*	*Total*
Production	E11	E12	E13	E14	E15	E16	E17			E110
Import	E21	E22	E23	E24				E28		E210
Export	E31	−E32	−E33	−E34				−E38		E310
Change in stocks	E41	E42	E43	E44						E410
Primary energy conswnption	E51	E52	E53	E54	E55	E56	E57	E58		E510
Stat. divergence	E61	E62	E63	E65	E65			E68	E69	E610
Power generation	−E71	−E72	−E73	−E74	−E75	−E76	−E67	E78		E710
Heat production	−E81	−E82	−E83	−E84	−E85	−E86	−E87	−E88	E89	E810
Fuel conversion	−E91	−E92	E93	−E94	−E95	−E96	−E97	−E98	−E99	E910
Own consumption	−E101	−E102	−E103	−E104					−E109	E1010
Network losses	−E111	−E112	−E113	−E114	−E11S			−E118	−E119	E110
Final energy conswnption	E121	E122	E123	E124	E125			E128	E129	E1210
Agriculture, fishing	E131	E132	E133	E134	E135			E138	E139	E1310
Industry	E14l	E142	E143	E144	E14S			E148	E149	E1410
Building	E151	E152	E153	E154	E155			E158	E159	E1510
Transport	E161	E162	E163	E164	E165			E168	E169	E1610
Communal sector	El11	E172	E173	E174	E175			E178	E179	E1710
Services sector	E181	E182	E183	E184	E185			E188	EJ89	E1810
Housing sector	E191	E192	E193	E194	E195			E198	E199	E1910

Indicator	*Coal*	*Crude oil*	*Petroleum product*	*Natural gas*	*Other fuels*	*Hydro and NWEI*	*NPP*	*Electric energyQ*	*Heat*	*Total*
Non energy use	E201	E202	E203	E204	E205					E2010

Source Bashmakov (2013)

and changes in these resources during the reporting period, the accounts are prepared in kind and in monetary terms.

The aim of the central analytical platform created at Federal State Statistic Service (Rosstat) to combine three types of accounting: statistical, accounting and tax. Already in 2019, Rosstat for the first time included the cost of natural resources in the balance of assets and liabilities of the SNA: minerals (mineral and energy resources), uncultivated biological resources of animal origin (hunting), uncultivated biological resources of plant origin (forest).

In the context of Industry 4.0 data collection systems are becoming significantly more focused on continuous data collection and analysis of incoming information.

At present, the completeness and accuracy of information that can be obtained from official questionnaires of Russian enterprises is a serious problem. For example, indicators related to the operation of power generation industries, production and distribution of energy in different questionnaires and reporting forms are presented in different ways, which lead to significant discrepancies and the need for expert assessments and adjustments. At the same time, the information accounting system of the Central Dispatching Office of the Fuel and Energy Complex (CDO FEC) of the Ministry of Energy of Russia[5] is more efficient. However, industry contradictions lead to the fact that the input data, in real time, arriving at the processing centers of the CDO FEC cannot be used for the purposes of statistical analysis. It seems necessary to resolve this issue at the government level.

Order No. 600 of the Ministry of Energy of Russia,[6] which determines the Procedure for drawing up fuel and energy balances, provides for accounting for the consumption of energy resources by type of economic activity in accordance with indicators of a special questionnaire. When filling out the indicators in accordance with international practice, the main branch of the economy or the type of activity is indicated, which is determined by the OKVED code. This Russian nomenclature is based on the UN International Classification (ISIC Rev.-4).[7]

Thus, it is possible to unambiguously attribute the consumption of each energy resource to a certain type of activity. The disadvantage of this approach is the fact that many enterprises have several types of non-core activities, using energy resources for different applications, while only one type of

organizations are responsible for methodological sophistication—the presence of an unambiguously understood content of indicators, methodology and algorithms for obtaining information and producing data.

[5] https://www.cdu.ru/company/ (accessed 25 July 2020).

[6] Text of the order. http://www.consultant.ru/document/cons_doc_LAW_125725/ (accessed 25 July 2020).

[7] https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf (accessed 25 July 2020).

Table 3 Comparison of the results of the analysis of Russia's electrical balance according to the methodology of Rosstat and IEA

Indicator	*Unit of measurement*	*Rosstat data*	*Calculations based on the lEA methodology*
Energy consumption in the economy	Million Ton of fuel equivalent (TOE)	No	993
Energy intensity of GOP in 2012 to the level of 2000	%	No	69.5
Share of fossil fuels in energy consumption	%	No	90.2
Electricity production	MiUion Ton of fuel equivalent (TOE)	368.4	131.5
Energy consumption in industry	Million Ton of fuel equivalent (TOE)	427.3	270.5
Share of electricity in the structure of household energy consumption	%	20.8	8.3

Source Slobodyanik (2018)

activity is indicated in the questionnaire (Form 4-TER).[8] Therefore, the entire consumption of energy resources falls on one OKVED code, which distorts the actual data.

All these problems lead to the fact that up to now there are serious discrepancies in the results and output data of the fuel and energy balances formed according to the methods of the IEA and Rosstat. Table 3 shows the differences in the results of calculating the electrical balance:

The use of energy statistics data for making management decisions in conditions of imperfect methodology for collecting and analyzing information leads to the fact that the quality of these decisions, including in the strategic perspective, may be insufficient, which seriously affects the prospects of the country's economic growth.

At present, forecast balances using models of the development of the energy sector and total economy are acquiring great importance. The forecast balances are an important source of practical recommendations for economists and politicians, since they actually contain trends and opportunities that characterize the current state of production and consumption of energy resources and bring out the issues of energy security and sustainability. The development of forecast fuel and energy balances requires the use of a wide range of tools and sources, which are shown in Fig. 2.

The compilation of FEB takes advantage of the modern features that arise during the process of engagement of the Russian economy in Industry 4.0

[8] Title of the questionnaire—form 4-TER.

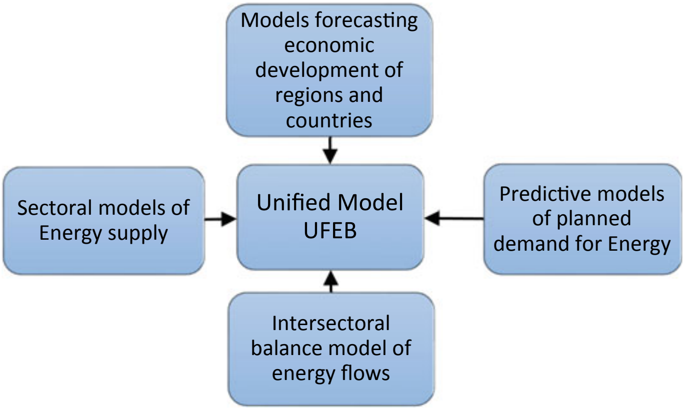

Fig. 2 Sources and tools for the development of forecast fuel and energy balances (*Source* Compiled on the basis the World Energy Balances [2019])

technologies. This is reflected in the ability to collect and analyze real-time information.

The analytical capabilities of the FEB data are outstanding. The study of changes in their structure over several years allows:

a. To take into account the interrelationships of various energy supply and energy consumption systems, assess the degree of their mutual complementarity and replaceability, and thereby increase the reliability of forecasting energy consumption parameters in industries and sectors of the economy (taking into account the presence of competition in various sectors of the economy for energy resources);
b. To reflect in an integral table all the most important energy connections and proportions: importance of certain energy resources in the energy balance, importance of certain sectors in the consumption of certain energy resources;
c. To create an information basis for the formation of a forecast model of the energy situation in some region or in the country in order to eliminate the negative consequences of climate change and the development of a "green economy", taking into account the requirements and new challenges of Industry 4.0.

4 Conclusion

Modern energy is a complex system that encompasses a number of independent industries organically united in the energy sector. The composition, quantitative ratios of types of economic activity and inter-production relations characterize the structure of the energy sector, and this structure is constantly changing, reflecting the level of development of science, technology, economy and energy policy of the state.

Comprehensive accounting with the help of fuel and energy balance of various external and internal factors will ensure the sustainable development of the country's fuel and energy complex and create a reliable basis for progressive economic development in the future. Opportunities provided by Industry 4.0 technologies promote to significantly speed up the receipt and processing of statistical information, as well as the provision of reports to stakeholders.

The most important issue that hinders the preparation of accurate and objective fuel and energy balances is the inaccessibility of data on the movement of fuel and energy resources from manufacturers-suppliers and intermediaries, and the unreliability on the consumers change of inventories. All the data on the calculated fuel and energy balance found in the scientific and reference literature are to a certain extent an approximate reflection of the reality in the Russian economy.

The indicators of Fuel and Energy Balance in the social sphere and the housing sector are presented in entirety, which makes it difficult to analyze the supply and demand for energy. The population, as the final consumer, must be provided with electricity, gas and heat at equilibrium prices. Government regulation of the level of social responsibility of businesses is essential for decision-making.

Based on the analysis, the authors revealed that in the process of forming a digital analytical platform in the system of the Rosstat, world experience is used—optimal conditions are created for the modern transformation of information support for energy statistics. Online systems for collecting, storing and processing information and using cloud storage are also becoming important for statistics in the energy sector in the context of Industry 4.0, with a high speed of processing input data being the determining factor.

In this regard, firstly, the necessity of methodological improvement of the problems investigated by the authors concerning the filling of the lack of official data through the simultaneous use of information from special censuses, administrative data and alternative sources was revealed. It is recommended to use municipal, regional and departmental statistics to enhance information support of FEB at various levels.

Second, the completion of the transformation of the national methodology in the energy sector in accordance with the practice of international organizations and international standards will contribute to the improvement of the system of indicators of energy statistics. The account of energy resources, to be created by 2024 within the framework of the SNA and SEEA, both in physical and value terms, are being formed taking into account the integration of accounting, statistical and tax reporting, integrated on the analytical platform being developed, and contributing to the global harmonization of all sources of official data.

Third, the need to strengthen the social orientation of the fuel and energy balance was identified, since the FEB indicators related to the housing sector are not given in details. This is the reason for the discrepancy between the need for energy resources and their satisfaction. This problem cannot be solved without ensuring proper state regulation in the social sphere.

Fourth, the issues of insufficient application of the analytical potential at all levels of forecast models of fuel and energy balance are generalized. With the expanded use of their data, practical government regulation will be more focused on the efficient use of energy resources, reducing the energy intensiveness of the country's GDP. Taking into account the solution of the problems associated with climate change and reducing the load on the environment, the need for the development of non-energy-intensive sectors of the economy is increasing.

5 Promising Areas for Further Research

The issues of the current state and prospects for improving the information support of energy statistics revealed in the article make it possible to identify new horizons for further research, such as: studying the impact of digital transformation of the economy on the energy statistics indicators listing. The present state and prospects for improving the information support for energy statistics discussed in the article reveal new horizons for further research, such as examining the impact of the digital transformation of the economy on the list of energy statistics.

The research interest is, first, to further explore the use of accounting, statistical and tax data to construct both the SEEA and the SNA Satellite Energy Account. Second, a specially organized survey may be conducted for one region, or one resource each, to assess the efficiency of their use.

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Evaluation of Investment Projects in Renewable Energy Sources in Industry 4.0

Irina V. Sokolnikova and Elizaveta A. Larkova

1 Introduction

The economy of the European Union is going to shift gradually from the commonly used hydrocarbons (like oil and gas) towards "green" energy. The latest news from the EU states that financial help that is aimed for overcoming COVID-19 aftermaths includes the implementation of green projects in every European country. Both European and USA governments have the aim to decrease the consumption of oil, coal and nuclear energy by 2030 and give up all these sources of energy by 2050 (IRENA Report, 2018). As a result, the most developed countries are going to use either "green" sources of energy (wind, sun, water) or condensed natural gas that is more eco-friendly resource that meets all Health Safety and requirements. Moreover, the president race in the United States of America helped to understand the importance of "green economy" in the foreseeable future as it became the key point in Joe Biden's campaign. Thus, the question of decarbonization is really crucial both for state authorities and for ordinary responsible consumers.

Not only European countries together with the USA are engaged in numerous alternative sources of energy projects but Russia is doing all its best in order to support global "green" trends. For example, there is The Russia Renewable Energy Development Association, a non-profit organization, with the aim to stimulate investments in the field of renewable sources of energy

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and to promote its use in the country in the foreseeable future. This organization's activities are aimed at effective implementation of solar, wind, biofuel and sea energy projects in Russia.

2 Materials and Method

Myers was the first to outline the need for application of real call options to study company growth prospects following strategic innovative decisions in 1977 and proving the usefulness of calculations with the help of the valuation theory for the financial markets (Santos, 2014). This is how an evaluation approach for projects in the areas with a large number of uncertainty factors appeared. These are the features typical of renewable energy. On the one hand, the margins of such projects are usually very low or negative, while on the other hand, development, expansion or modification options appear during implementation of the project, which boost its financial indicators significantly (Aguiar et al., 2020). Thus, some wind power stations of European wind energy projects have seen negative subsidies this year. Negative subsidies mean that the project is capable of returning the initial capital expenditure without state aid.

Table 1 presents a chronological order of real options development to assess effectiveness of investment projects, which currently lack relevant information. All researchers agree with the need to use the real option methodology to assess new strategically important directions to develop companies with a significant uncertainty factor.

Our analysis helps us formulate a recommendation on the need of evaluation of "green" energy investment projects with the application of real options. A multistage option and an option to expand will be the best here.

3 Results

Nowadays many companies that are involved in traditional hydrocarbon production are focusing on the production of the alternative sources of energy as well. Thus, famous British transnational oil and gas corporation "BP" has been focusing on alternative sources of energy development for the last 10 years. For instance, BP and Brazilian Bunge (bioenergy and sugarcane ethanol businesses) formed a joint-venture that is called BP Bunge Bioenergia. The new company has a production capacity of 32 million metric tones of sugarcane per year. Moreover, BP managed to increase its share in Light source BP that is going to produce 10GW of solar energy by 2023 (BP Report, 2020). One more interesting project where BP participates too is the production of bio-isobutanol from corn that is widely used as paints and lubricants. All the above mentioned projects have one common thing in their core: BP wants to develop and to bring to our everyday life digital platforms that make it much easier for every person to be connected to low carbon electricity for powering their homes and cars. The company is doing all its best to explore

Table 1 Development of assessment methods for evaluation of investment projects with the use of real options methodology

Year of publication	*Researcher*	*Ideas for development of investment project effectiveness analysis methods*
1982	Hayes, Garvin	Confirmed the faults of the discounted cash flow method, which fails to take into account managerial flexibility during investment and showed that its use leads to lower competitiveness of companies
1987	Myers	Proved that the discounted cash flow methodology fails to provide an accurate evaluation of investment projects with new tactical and strategic development directions; demonstrated that the real options methodology will be the best in such cases
1985–1987	Mason and Merton, Trigeorgis and Merton	Established the necessity and sufficiency of application of the discounted cash flow method for the projects without uncertainty. And on the contrary, uncertainties in project development conditions application of real options to analyze the impact of managerial flexibility on a project
1992	Brealey, Myers	Discovered that it is the prospects of R&D results use become a signal for the management to continue or terminate further research. If calculations point to a negative result for further R&D, the project is terminated, the loss is restricted to investment in R&D. If analysis shows a positive result for further R&D at this stage, the managers continue the research, which is in fact means exercising a call option
1993	Trigeorgis	Classified the options into the following categories—an option to defer, a stage option, an option to scale, an option to abandon, an option to switch, an option to expand and multiple choice option
1994	Copeland and others	Proved that the options methodology contains both the features of a discounted cash flow method and a tree of objectives

(continued)

Table 1 (continued)

Year of publication	*Researcher*	*Ideas for development of investment project effectiveness analysis methods*
1994	Dixit and Pindyck	Pointed to the fact that the traditional methodology does not account for the additional values created by the possibility to defer the launch of a project until favourable conditions appear. The discounted cash flow methodology views projects as the plans, which can only be implemented now or never. This condition, of course, distorts evaluation of project effectiveness
1995	Ross	Also states that the classic dynamic methods, which produce simplified judgements whether to implement a project or not, produce wrong solutions. A project, which is inefficient today, can become highly marginal in different conditions. Uncertainly becomes a source of adding value
2001, 2003	Copeland and Antikarov	Published a guide to application of real options; suggested using a discounted value of an investment project without accounting for flexibility as the basic asset of a twin security instead of a replicative portfolio. The next step is to establish the value of the security as if it were traded on the open financial market. In this case, there searchers rightly believe that nothing correlates with a project better than the project
2004	Copeland and Tufano	Proved that the difficulty of real option valuation can be removed by the use of binary trees
2006	Costa Lima and Suslick	Presented alternative quantitative methods based on the current value of future cash flows and imitation modelling using the Monte Carlo method to assess volatility of project parameters
	Damodaran	A practical guide to evaluate project risks using the real options methodology; studied special features of real options use for different industries
2011	HahnandDyer	Developed stochastic price models for goods using binary strings

Source Developed by the authors using Cox et al., 1979; Damodaran, 2015; Kester, 1984; Santos, 2014;Schwartz & Trigeorgis, 2001 opportunities for value creation at the intersection between natural gas and renewable sources of energy.

However, British Petroleum is not the only company that is partially engaged in renewable sources of energy projects. Russian state corporation, Rosatom, has already started to implement "green" projects connected with windmills since 2018. The company entered the wind energy market successfully. According to preliminary estimations, the company will be able to generate 3.6 GW by 2024 that will help to reach the annual turnover at the amount of US 1,6 billion (RREDA, 2020). This amount will guarantee the demand for production of windmills, wind turbines and the rest of wind farms, required infrastructure together with support services.

As wind power is one of the most rapidly developing field in renewable energy sources, the question about how companies should consider all the opportunities to make such projects more profitable taking into account current global trends and corona-crisis aftermaths arises. In order to increase the managerial flexibility in investment decision-making process, to help the company to adjust both constantly changing external market conditions and to final consumer needs, the traditional method for investment project valuation should be considered together with real options (Zhang et al., 2016). The additional factor of project attractiveness is a decision of the Russian government to extend a renewable energy programme for the wholesale market until 2035.

One of the traditional methods for project valuation is the creation of discounted cash-flow model (DCF). Using this tool, the value of the project can be found by summarizing the discounted cash-flow over the project life period. Nevertheless, DCF should be estimated together with option to expand (Mendez et al., 2009). Evaluation of economic effectiveness of a project with the help of a simplified DCF methodology is shown in Table 2. When compiling the financial model we assumed that in the best case scenario of project development the windmills construction business can be expanded by 35% in the geographic zones with the climate optimal by several indicators. As a result, the project will generate higher sales.

The expansion option is a European call option (it means that it can be executed only at the expiration date comparing to the American one). Table 3 below presents both expansion option calculation and required input parameters.Врезультатерасширенияпроекта the sum of the discounted cash-flow and the option to expand will be390 668 163 RUR.

One more way for project valuation is the project presentation as a sequential compound option. For calculation of real option value that includes the sequential compound option it is required to estimate the volatility parameter (σ) based on Monte-Carlo method, current value of the underlying assets (So), cost of investment (strike price in other word X) and time period before the option execution (T).

Based on the commonly used Black–Scholes model, Table 4 was created.

Table 2 Simplified DCF model for awind project

		2025	*2026–2041*	*2020–2041*
		1 year	16 years	22 years
Revenue	RUB	197,400,00	1,069,182,073	5,878,192,711
OPEX	RUB	−72,750,000	−394,037,466	−2,166,355,216
EBITDA	RUB	124,650,000	675,144,607	3,711,837,494
Margin	%	63%	63%	63%
Taxes	RUB	6,058,560	49,834,680	490,257,940
NWC, change	RUB	−1,622,466	−1,898,055	−3,418,291
CAPEX	RUB	−3,000,000	−16,248,968	−1,076,334,236
FCFF	RUB	106,590,000	573,528,960	2,099,984,319
NPV	RUB	63,767,522		
IRR	RUB	14.1%		
Payback period for FCFF	Years	8		

Source Own calculations

Table 3 Expansion option calculation

Input parameters		
So	Current asset value	140,403,550 rub
X	Strike price	300,489,510 rub
T	Time to expiration	6 years
Σ	Volatility	29.70%
R	Risk-free rate	6.10%
Option parameters		
d1	0.14	N(d1) = 0.56
d2	−2.41	N(d2) = 0.01
Option value	365,492,409 rub	

Source Own calculations

Table 4 above is constructed based on the predecessor-successor principle. It means that the value of option to develop will depend on the values of option to expand and the option to construct. The last two options become the underlying asset value for the option to develop and the value of the option to develop becomes the underlying asset value for the option to identify. The value of option to identify will be 396,971,732 RUR. At the same time it is the total value of the sequential compound option for the chosen wind project. The logic of a sequential option is presented in Fig. 1. Moreover, the value of the company that is going to implement this project can be potentially increased by this amount.

Generally speaking, it can be stated that the value of the investment project estimated with the help of sequential option model is significantly higher than the same project but estimated only using the traditional discounted cash flow

Table 4 Sequential option calculation

	Option to construct	*Option to develop*	*Option to identify*
So (*option value*)	36,549,2 09	785,155,744	884,406,812
X	911,489,510	329,000,000	47,000,000
T	6	1.5	0.5
Σ	27.18%	27.18%	29.70%
R	6.10%	6.10%	6.10%
Output parameters			
d1	−0.39	3.12	10.07
d2	−2.02	2.71	9.86
N(d1)	0.35	1.00	1.00
N(d2)	0.02	1.00	1.00
Option value	785,155,744	884,406,812	396,971,732

Source Own calculations

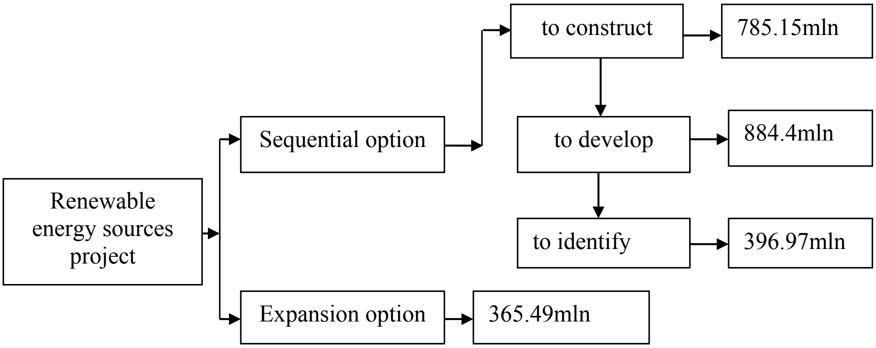

Fig. 1 Decision tree for renewable energy project (*Source* Composed by authors)

method. Thus, the first tool helps to show the investors additional project value that comes from the managerial flexibility.

Overall, it can be concluded that any oil and gas company that is engaged in renewable energy project can benefit if it is willing and able to diversify its business portfolio with innovative and unique to some extant projects like wind firms. The performed calculations show how it is possible to turn not very profitable project (according to traditional DCF method) into profitable one (using sequential option calculation). One more important thing is that real options technique can help to increase the company value and to attract potential investors for project implementation.

4 Conclusions/recommendations

Conclusions: the urgency of the "green" projects and the need of their evaluation through real options.

In the conclusion it can be said that green projects are a very topical issue in the current constantly changing global environment. Many countries (the USA, the UAE, the European Union etc.) are going to do all their best in order to switch from traditional sources of energy (like oil, gas, coal and nuclear energy) to the more "eco-friendly" sources like wind, solar, water. As it has already been mentioned, COVID-19 aftermaths were a certain trigger in the more rapid development of green projects. Many anti-crisis measures are focused on the increase of renewable energy projects all around the world.

Each project can be considered as an investment meaning that money spent today will be more beneficial in the foreseeable future. That is why looking closer to each green projects, a lot of questions concerning different risks and uncertainties and the most appropriate method for its valuation arise.

Traditional tools (like discounted cash flow model) may undervalue the project or to estimate its profitability not very accurate. In order to eliminate all these issues, it is worth paying attention to real options technique for project valuation. Still, the combination of DCF approach and real options provides the best way for estimation that reduces all pitfalls that are come across applying only one of these methods.

Real options are usually used in industries with high degrees of risks, uncertainties and complex production process, such as oil and gas industry or energy sector. Managerial flexibility that is inherent in, at first sight, unprofitable projects can be a source of value.

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Financial Management of Safe Production in the Green Model of Industry Development 4.0 in the Regional Economy

Tatiana M. Rogulenko, Anna V. Bodiako, Svetlana V. Ponomareva, and Viktor V. Gorlov

1 Introduction

Environmentally safe production is the most important priority of modern sustainable development goals, initially based on the concept of sustainability of economic systems. In achieving this priority, three periods can be distinguished, each of which is associated with the predominance of a certain managerial approach. The first period dates back to the second half of the twentieth century, when industrial development reached such a high level that the enormous environmental damage it inflicts could no longer be hidden from the public, and neither the state nor business could no longer ignore it.

At that time, the approach to safe production was to limit industrial production. Since the decline in economic growth was contrary to the interests of the participants in the global competition, the development of safe industries

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took place at a slow pace. The time frame of the second period covers the beginning of the twenty-first century, when circular business practices became available and more widespread. The approach to safe production of the period was related to the transition to renewable energy and secondary raw materials.

The modern—third period began from 2010 to 2015. and continues to this day. It is connected with the formation of industry 4.0 and involves the management of the development of safe production through green digital technologies. The introduction of environmentally oriented digital innovation is accessible to all countries and makes it possible to achieve the goals of sustainable development in the aspect of environmental safety of production everywhere. But the problem along the way is uncertainty about the financial management of safe production in the green model of industry development 4.0.

The key question is which investment objects should receive the first and most financial support: new technologies (intellectual property objects) or new production equipment (new buildings, structures, machines, vehicles, etc.). This article is aimed at finding an answer to the question posed on the example of the regions of modern Russia and developing the scientific foundations of financial management of safe production in the "green" model of industry development 4.0 in the regional economy of Russia.

2 Literature Review

Green economics as an environmentally friendly trajectory for the development of economic systems is studied in Asongu and Odhiambo (2020), Bogoviz (2019a, 2019b), and Khan et al. (2020). The financial aspect of the formation and development of industry 4.0 is discussed in the works of Bolgova (2017), Guseva et al. (2019), Medentseva (2017), Popkova and Parakhina (2019), Sergi et al. (2019a, 2019b, 2019c) and Tarakanov et al. (2020).

A literature review showed that the green and digital economies are mainly studied separately and the systemic scientific idea of the green model of industry development 4.0 has not yet been formed (the first gap). It was also established that financial management issues were studied mainly in relation to industry 4.0, but not to environmentally friendly production (second gap). The specifics of the introduction of environmentally oriented digital innovations and the management of this process at the regional level are not defined (third gap). This article is intended to comprehensively fill the identified gaps.

3 Materials and Method

Achieving this goal involves three research objectives. The first task: to determine the impact of digitalization on the development of safe production in the regions of Russia in 2021, that is, to prove the presence and regularity of environmental damage to digitalization.

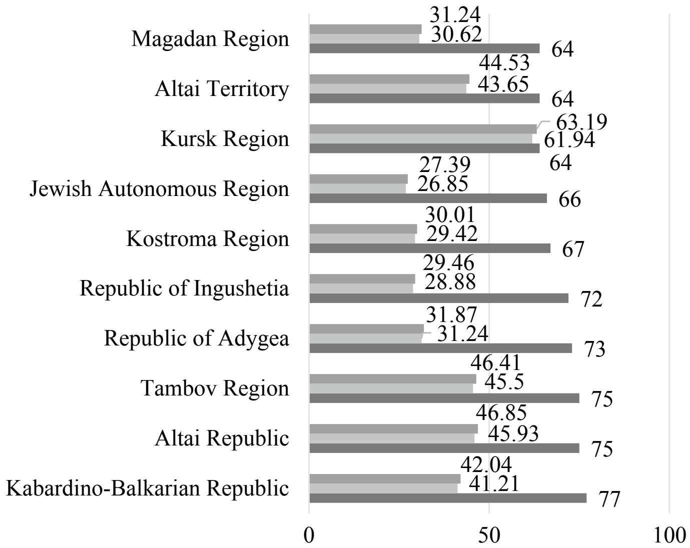

Fig. 1 Statistics of the green and digital economy in the regions of Russia in 2021 and the forecast of digital development for 2023 (*Source* Built by the authors on the basis of the materials of Green Patrol [2021] and Institute of Scientific Communications [2021])

The second task: on the basis of the forecast of digitalization of the regional economy of Russia for the period until 2023, determining the consequences of its digital development for production safety, that is, assessing the potential environmental damage of digitalization. The third task: to determine the preferred financing facilities for green digital innovations and the optimal investment structure in the green model of industry development 4.0 in the regional economy of Russia. In order to solve the tasks, a sample of the top 10 regions of Russia was formed in terms of the level of development of the "green" economy (according to the value of the environmental index), presented in Fig. 1.

Statistics of safe production in the green model of industry development 4.0 in the regional economy in 2021 are given in Table 1.

Statistics of industry financing 4.0 in the regional economy of Russia in 2021 are given in Table 2.

4 Results

The impact of digitalization on the development of safe production in the regions of Russia in 2021 is defined in Fig. 2.

According to Fig. 2, digitalization negatively (negative regression coefficients) affects the development of safe production in the regions of Russia in 2021. The impact of digitalization on reducing environmental pollution is

Table 1 Percentage of organizations implementing environmental innovations that improve environmental safety in the production process

Region	*Reduction of material costs for production of a unit of goods, works, services*	*Reduction of energy consumption for production of a unit of goods, works, services*	*Emission reduction to the atmosphere of carbon dioxide (CO_2)*	*Replacement of raw materials and other materials with safe or less hazardous*	*Reduction of environmental pollution (air, land, water, noise)*
Kabardino-Balkarian Republic	100.0	100.0	100.0	50.0	100.0
Altai Republic	0	100	0	0	100
Tambov Region	50	25	0	0	100
Republic of Adygea	0	100	100	100	100
Republic of Ingushetia	0	100	0	0	0
Kostroma Region	50	33.3	33.3	66.7	33.3
Jewish Autonomous Region	100	100	100	100	100
Kursk Region	50.0	33.3	33.3	66.7	25.0
Altai Territory	0	16.7	0	66.7	66.7
Magadan Region	50	50	0	50	50

Source Compiled by the authors based on the materials of Federal State Statistics Service (2021)

Table 2 Share of the type of fixed assets in the structure of investments in fixed assets, %

Region	*Residential buildings and premises*	*Buildings (except residential) and structures, land improvement costs*	*Machinery, equipment, vehicles*	*Intellectual property*	*Other*
Kabardino-Balkarian Republic	25.2	44.7	24.4	0.5	5.2
Altai Republic	13.0	62.2	17.7	0.1	7.1
Tambov Region	28.7	43.2	25.1	0.1	2.9
Republic of Adygea	4.0	50.4	44.4	0.0	0.1
Republic of Ingushetia	5.3	82.3	9.8	0.5	2.1
Kostroma Region	19.0	36.5	41.4	0.5	2.6
Jewish Autonomous Region	6.3	67.8	25.5	0.0	0.3
Kursk Region	6.3	44.1	46.6	0.2	2.8
Altai Territory	20.0	35.2	39.3	0.7	4.8
Magadan Region	1.1	47.8	46.8	4.2	0.1

Source Compiled by the authors based on the materials of Rosstat (2021)

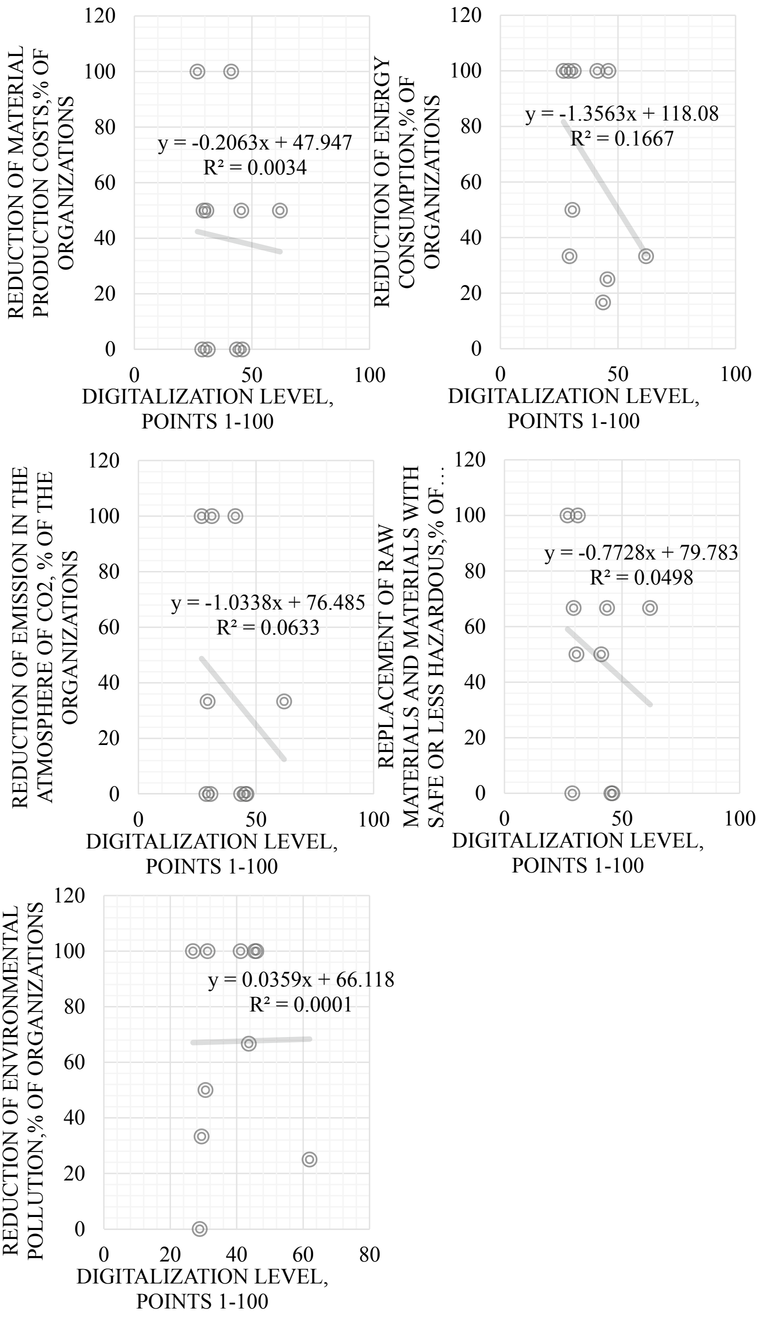

Fig. 2 The impact of digitalization on the development of safe production in the regions of Russia in 2021 (*Source* Calculated and built by the authors)

negligible (correlation 0.01%). The digitalization of the regions of Russia in 2021 averages 38.524 points, and, according to the forecast (Fig. 1), by 2023 it will increase to 39.299 points. When substituting the digitalization value (x) for the 2023rd year in the regression equations in Fig. 2, it was revealed that in this case:

- reduction of material costs for production will decrease by 0.40%;
- reduction of energy consumption will decrease by 1.60%;
- reduction of emissions into the atmosphere CO_2 will decrease by 2.19%;
- replacement of raw materials and materials with safe or less hazardous ones will decrease by 1.19%.

In order to determine the preferred financing facilities for green digital innovations and the optimal investment structure in the green industry development model 4.0 in the regional economy of Russia, a correlation analysis was carried out, during which it was revealed that:

- reduction in material costs of production is positively related to investments in residential buildings and premises (correlation 21.69%);
- the reduction in energy costs is positively related to investments in buildings (other than residential buildings) and structures and costs of land improvement (correlation 73.19%);
- reduction in atmospheric emissions CO_2 positively linked to investments in machinery, equipment and vehicles (correlation of 10.90%);
- the replacement of raw materials with safe or less hazardous materials is positively linked to investments in machinery, equipment and vehicles (65.24% correlation).

In order to establish more precise dependencies of the selected indicators, the regression curves in Fig. 3 are drawn from Table 1.

Based on the materials of Fig. 2, it was revealed that the environmental damage of digitalization in the regions of Russia until 2023 can be completely leveled due to:

- increase the share of investments in residential buildings and premises to 13.07%;
- increasing the share of investments in buildings (except residential) and structures and improving land up to 52%;
- increase the share of investments in machinery, equipment and vehicles to 34.24%.

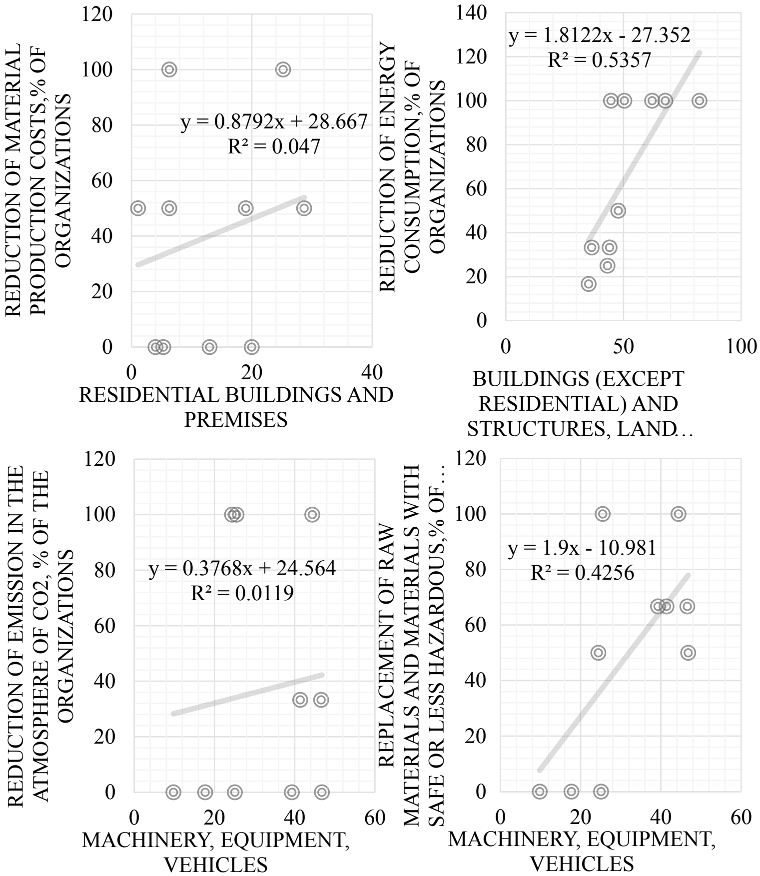

Fig. 3 Impact of financial management of industry 4.0 on the development of safe production in the regions of Russia in 2021 (*Source* Calculated and built by the authors)

5 Conclusion

On the example of the regions of Russia in 2021, it was revealed that the preferred object of financing "green" digital innovations and the optimal investment structure in the green model of industry development 4.0 in the regional economy of Russia is new production equipment (new buildings, structures, machines, vehicles, etc.). Quantitative guidelines for the financial management of safe production in the green model of industry development 4.0 in the regional economy of Russia for the period up to 2023 have been proposed.

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Development of Smart Production in Regions That Implement the Resource-Based Models of Economic Growth: Financial Limitations and Consequences for Ecological Safety and Climate Change

Aleksei V. Bogoviz, Svetlana V. Lobova, and Alexander N. Alekseev

1 Introduction

The real sector of economy is the basis of economic system's stability against crises; however, this basis became weaker in the conditions of the COVID-19 pandemic, and a clear differentiation between mining industry and processing industry has formed. At the global level, resource markets have suffered the largest losses due to the crisis, which was expressed, in particular, in the historical drop of oil prices. On the contrary, the markets of processing industry showed a rise—which example is the quick increase of demand for medical equipment (e.g., machines for artificial lung ventilation).

Though the Russian economy is considered to be dependent on the world resource markets, it has shown a relatively larger sustainability against the COVId-19 crisis—due to the developed processing industry, which share in the Russia's GDP constitutes 17% (processing industry—10.9% (Rosstat 2021). The situation at the regional level deserves special attention, for industrial production influences not only the regions' economic growth but also the ecological situation. In the conditions of the COVID-19 pandemic and crisis,

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the ecological risks of development of the real sector of economy are especially high, since the control over industrial production is reduced, and the interests of corporate ecological responsibility were pushed to the background amid the regional companies' fight for survival.

The following hypothesis is offered here: development of smart production in regions with industrial and, in particular, resource-based models of economic growth, allows reducing the negative consequences for ecological safety and climate change during crises. The purpose of this research is to study the consequences of development of smart production in regions that implement the resource-based models of economic growth for ecological safety and climate change and to determine financial limitations on this path by the example of Russia's regions in the conditions of the COVID-19 pandemic and crisis.

2 Literature Review

Resource-based models of economic growth are studied in detail in the works Popkova (2019), Sergi (2019), Popkova and Sergi (2018), and Vivas Lalinde et al. (2019). The fundamental and applied issues of development of smart production are also considered in the works Popkova et al. (2020a, 2020b), Popkova and Sergi (2021), and Queiroz et al. (2020). However, the issue of development of smart production during implementation of resource-based models of economic growth has the following gaps:

- uncertainty of specifics at the regional level;
- unclear differences between industrial (processing and resource-based) models;
- insufficiently detailed elaboration of the financial limitations;
- insufficient elaboration of the essence of consequences for ecological safety and climate change;
- disregard of the unique experience of the COVID-19 pandemic and crisis.

In this chapter, we try to fill the above gaps.

3 Materials and Method

To check the offered hypothesis with the use of correlation analysis, we find the interdependence between the manifestations of development of smart production in regions with ecological safety and climate change (industrial and ecological index) and financing of smart production (expenditures for ICT).

To obtain the most informative results, we study industrial regions of Russia that include regions implementing the processing models of economic growth (the share of mining industry is below 2%) and regions implementing the

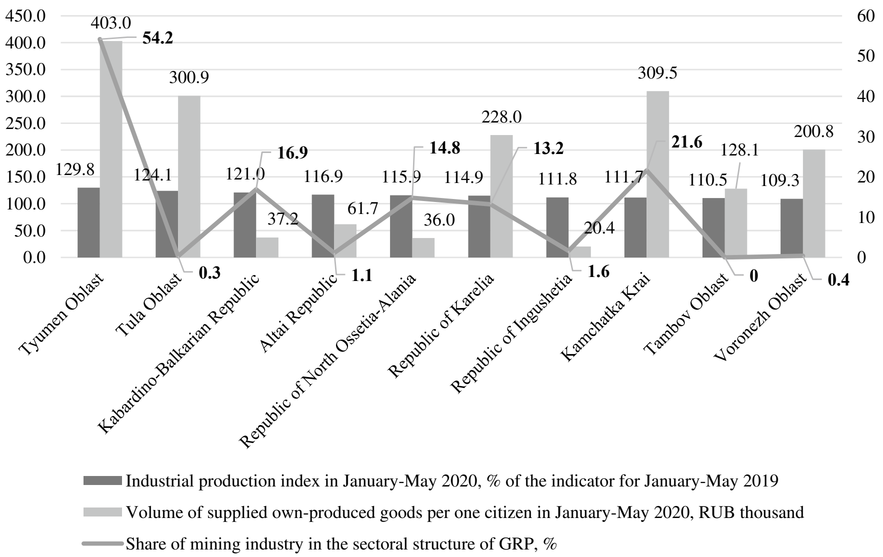

Fig. 1 Statistics of industrial production in regions with processing and resource-based models of economic growth in the conditions of the COVID-19 pandemic and crisis (*Source* Compiled by the authors based on RIA Novosti [2021] and Rosstat [2021])

resource-based models of economic growth (the share of mining industry is above 10%). The sample contains top 10 regions of Russia by the industrial production index in the conditions of the COVID-19 pandemic and crisis (Fig. 1).

Statistics of ecological security and climate change and the financial support for development of smart production in regions of the sample are given in Table 1.

Statistics of the manifestations of development of smart production in regions of the sample are given in Table 2.

On the basis of the correlation dependencies, we determine weight coefficients, with the help of which—according to the T.L. Saaty's analytic hierarchy process—we evaluate and compared the index of contribution of development of smart production to ecological safety and climate change in regions of Russia that implement the processing and resource-based models of economic growth.

4 Results

To determine weight coefficients of significance of each separate technology, we use the data from Tables 1 and 2 to calculate correlation between the manifestations of development of smart production in regions with ecological

Table 1 ICT expenditures and the industrial and ecological index in Russia's regions in 2020

Region	*Total ICT expenditures per capita, RUB*	*Industrial and ecological index, points 1–100*
Tyumen Oblast	2,254.1	59
Tula Oblast	1,184.2	37
Kabardino-Balkarian Republic	546.8	30
Altai Republic	1,878.0	47
Republic of North Ossetia-Alania	823.7	37
Republic of Karelia	1,003.5	56
Republic of Ingushetia	848.2	35
Kamchatka Krai	1,345.3	41
Tambov Oblast	557.9	66
Voronezh Oblast	899.6	40

Source Compiled by the authors based on CNews Analytics (2021) and Green Patrol (2021)

Table 2 Statistics of the manifestations of development of smart production in Russia's regions in 2020

Region	*Share of organizations that use special software:*				
	For R&D, %	*For design, %*	*For managing the automatized production and/or certain technical means and technological processes, %*	*For solving organizational, managerial, and economic tasks, %*	*CRM, ERP, SCM-systems, %*
Tyumen Oblast	4.4	17.2	23.1	59.5	24.8
Tula Oblast	5.0	15.7	18.5	55.9	23.0
Kabardino-Balkarian Republic	3.3	7.2	8.1	33.4	13.4
Altai Republic	2.2	7.0	11.0	52.0	11.1
Republic of North Ossetia-Alania	3.1	7.2	10.7	37.5	10.2
Republic of Karelia	3.6	11.9	16.0	56.9	17.7
Republic of Ingushetia	2.1	5.3	8.3	36.6	16.5
Kamchatka Krai	2.7	11.9	15.8	57.3	12.2
Tambov Oblast	3.8	9.9	16.0	63.0	19.1
Voronezh Oblast	5.8	13.2	15.5	56.4	22.7

Source Compiled by the authors based on Rosstat (2021) safety and climate change and financing of smart production in resource-based and processing regions of Russia in 2020 (Fig. 2).

As shown in Fig. 2, special software for R&D does not depend on financing of R&D, while the implementation of other smart technologies is largely determined by the volume of financing. The index of contribution of development of smart production to ecological safety and climate change in regions of the sample is calculated in Table 3, which also show products of the indicators from Table 2 (in fractions of 1) and their weight coefficients from Fig. 2.

The index of contribution of development of smart production to ecological safety and climate change in regions of Russia that use the processing and resource-based models of economic growth in 2020 is shown in Fig. 3.

As shown in Fig. 3, development of smart production in regions that implement the resource-based models of economic growth in Russia contributes (large and positive contribution) to provision of ecological safety and reduction of climate change; the corresponding indices are as follows: 0.75 in Tyumen Oblast, 0.38 in the Kabardino-Balkarian Republic, 0.42 in the Republic of North Ossetia-Alania; 0.64 in the Republic of Karelia, and 0.62—in Kamchatka Krai. On the whole, this index is higher in regions with the processing models of economic growth.

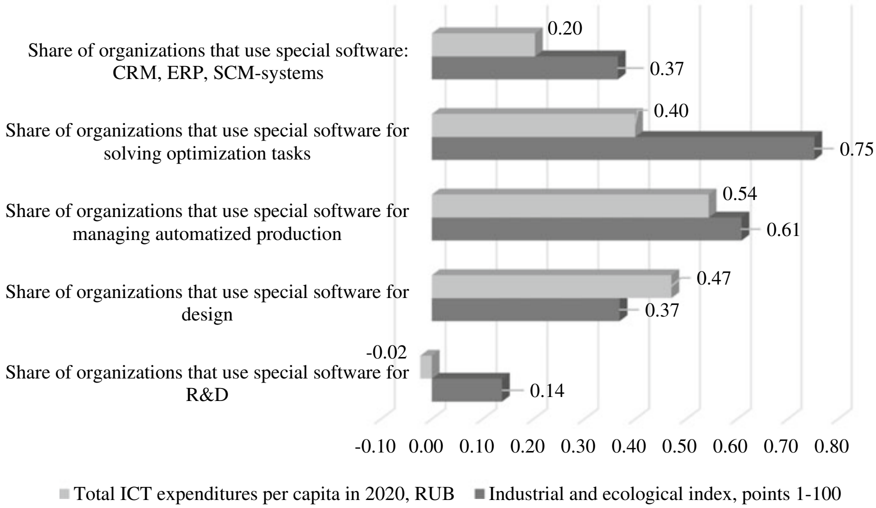

Fig. 2 Correlation between the manifestations of development of smart production in regions with ecological safety and climate change and financing of smart production in resource-based and processing regions of Russia in 2020 (*Source* Compiled by the authors based on RIA Novosti [2021] and Rosstat [2021])

Table 3 Calculation of the index of contribution of development of smart production to ecological safety and climate change in regions of the sample

Region	*Using special software for R&D*	*Using special software for R&D: design*	*Using special software for R&D: managing automatized production*	*Using special software for R&D: solving organizational tasks*	*Using special software for R&D: CRM, ERP, SCM-systems*
Tyumen Oblast	0.01	0.06	0.14	0.45	0.09
Tula Oblast	0.01	0.06	0.11	0.42	0.09
Kabardino-Balkarian Republic	0.00	0.03	0.05	0.25	0.05
Altai Republic	0.00	0.03	0.07	0.39	0.04
Republic of North Ossetia-Alania	0.00	0.03	0.07	0.28	0.04
Republic of Karelia	0.01	0.04	0.10	0.43	0.07
Republic of Ingushetia	0.00	0.02	0.05	0.27	0.06
Kamchatka Krai	0.00	0.04	0.10	0.43	0.05
Tambov Oblast	0.01	0.04	0.10	0.47	0.07
Voronezh Oblast	0.01	0.05	0.09	0.42	0.08

Source Calculated and compiled by the authors

5 Conclusion

Thus, the offered hypothesis has been proved, and the following conclusions have been made. Development of smart production in regions that implement the resource-based models of economic growth is especially important in the conditions of the COVID-19 pandemic and crisis, since it allows ensuring ecological safety and the fight against climate change. The positive contribution is most vivid in Tyumen Oblast (0.75).

In regions with the processing models of economic growth, the advantages of smart technologies for ecological safety and climate change are more vivid than in regions with resource-based models of economic growth. The use of software for R&D is the least significant factor of ecological security and climate change and does not depend on financing, while the financial limitations in the conditions of the COVID-19 pandemic and crisis largely determine the development of smart production in Russia's industrial regions.

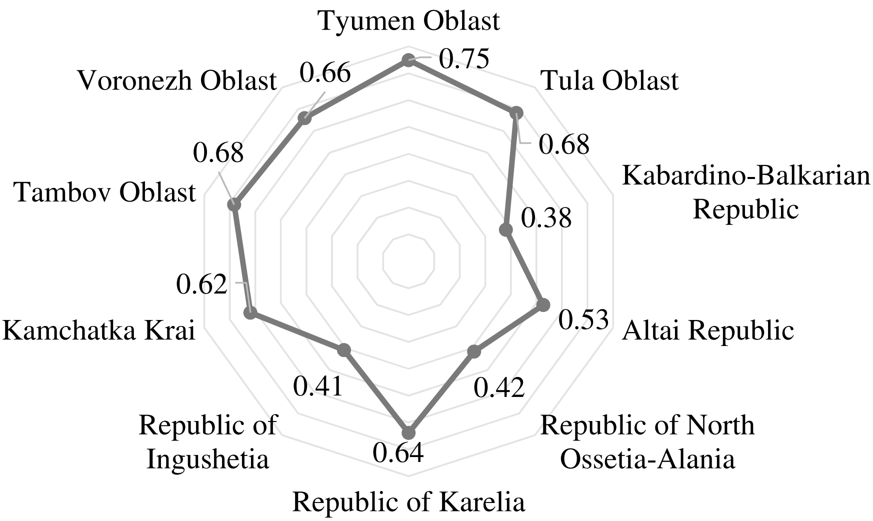

Fig. 3 The index of contribution of development of smart production to ecological safety and climate change in regions of Russia that use the processing and resource-based models of economic growth in 2020 (*Source* Calculated and compiled by the authors)

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Financial Strategy for Energy Development of Russian Regions in Industry 4.0 for the Period up to 2030 in Order to Achieve Sustainable Development and Security Goals

Tatiana D. Malyutina

1 Introduction

In the environment of industry 4.0, the digitalization of energy is a promising direction for the sustainable development of society and the economy and ensuring environmental security. Much attention is currently being paid to this area in Russia. By the Decree of the President of the Russian Federation dated 07.05.2018 No. 204 (paragraph 11), the need for a digital transformation of the energy infrastructure of Russia is outlined. In this regard, the Ministry of Energy of the Russian Federation (2021) launched the departmental project "Digital Energy." Although the project was originally focused on the period until 2024, due to the pandemic COVID-19 it is likely to be extended until 2030.

The project presented ambitious plans to improve energy security through reducing accidents in energy and uninterrupted energy supply. But for the successful implementation of the project, it is necessary to overcome the contradiction between the priorities set by the state and the practical activities of economic entities. The digitalization of energy should not be limited to the unilateral development of the energy sector of the economy, but should be carried out systematically and also cover the introduction of energy innovations by enterprises in order to reduce energy consumption and switch to alternative energy.

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The problem also lies in the fact that the required financial support for the digitalization of energy is not defined at the regional level, due to which the transfer of national plans for their implementation to the regional level is difficult. This research is designed to solve the problem and bridge the gap between the state plan and the practice of regional entrepreneurship through the development of a financial strategy for the development of energy in the regions of Russia in industry 4.0 for the period until 2030 in order to achieve the goals of sustainable development and security.

2 Literature Review

The concept of digital energy, the need for it and the prospects for its formation in modern economic systems are defined in the works of Abramova et al. (2019), Chaldaeva (2019), Isingoma-Wakaisuka et al. (2020), Popkova and Sergi (2021), Popkova et al. (2019a, 2019b). The contribution of energy to sustainable development goals and security is reflected in the work of Cao et al. (2020), Kwakwa (2020a, 2020b), Lange Salvia et al. (2020), Li et al. (2020), Romero-Rodríguez et al. (2020), and Unuigbe et al. (2020).

At the same time, there are a number of research gaps, including insufficient elaboration of the prospects for digitalization at the regional level in the country, as well as uncertainty in the financial provision of digital energy. In order to fill the identified gaps in this work, a systematic study is being carried out and a financial strategy for the development of energy in the regions of Russia in the industry 4.0 for the period until 2030 is being developed in order to realize the goals of sustainable development and security.

3 Materials and Method

In order take into account the specific context of industry 4.0. as well as the most accurate and reliable study of digital energy in this work, the research is carried out on the basis of a sample from the top 10 regions of Russia in terms of the level of informatization of society and the economy (Fig. 1).

As shown in Fig. 1, the level of informatization of society and economy is highest in Moscow (0.6631), and it is the least expressed among the sample regions, but also quite high in the Republic of Tatarstan (0.4892). The first part of the study determines the regression dependence of the coverage of the business with energy innovations and wear and tear of equipment in the energy sector on the volume of investments in fixed assets in the energy sector in the sampling regions in 2020 based on the materials of Table 1.

In the second part of the research, on the basis of the obtained regression dependence, the necessary volume of investments in fixed assets in the energy sector is identified in order to achieve full (100%) coverage of the business with energy innovations, as well as reduce wear and tear of equipment in the energy sector to a minimum level (20%). This allows you to determine the

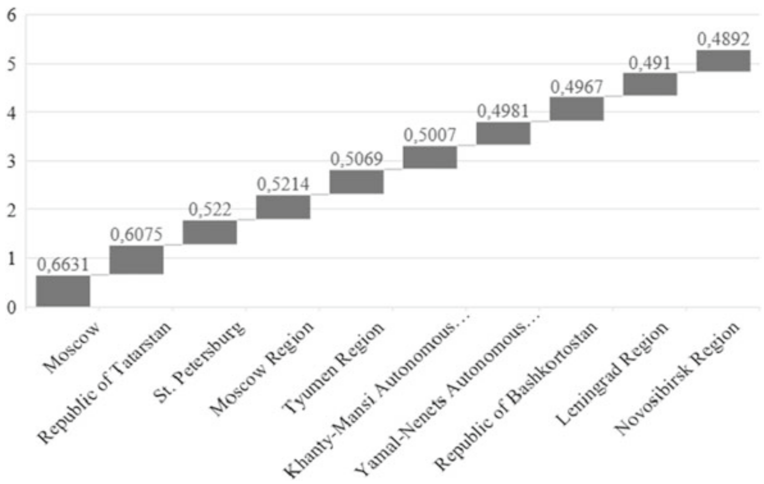

Fig. 1 Top 10 regions of Russia by level of informatization (*Source* Built by the authors on the basis of materials of the Ministry of Digital Development, Communications and Mass Communications of the Russian Federation [2021])

required amount of financing for digitalization and demand, and is offered in the energy markets of Russia until 2030.

4 Results

In order to form a financial strategy for the development of energy in the regions of Russia in the conditions of industry 4.0 for the period until 2030, in order to achieve the goals of sustainable development and ensure safety, we will refer to the results of regression analysis of the materials of Table 1.

Figure 2 shows that with an increase in the volume of investments in fixed assets in the energy sector in the sampling regions in Russia in 2020 by 1 million rubles. business coverage with energy innovations increases by 0.0001%.

Figure 3 shows that with an increase in the volume of investments in fixed assets in the energy sector in the sampling regions in Russia in 2020 by 1 million rubles. equipment wear and tear in the energy sector is reduced by 0.00001%. The regression equations obtained in Fig. 3 reveal the necessary amount of investment in fixed assets in the energy sector to achieve full (100%) coverage of the business with energy innovations, as well as reduce equipment wear and tear in the energy sector to a minimum level (20%).

Figure 4 shows that in order to fully (100% of enterprises) capture business with energy innovations in the regions of Russia with a developed industry 4.0, it is necessary to increase the volume of investments in fixed assets in the energy sector to 426,200.25 million rubles, that is, 16 times compared to 2020 (26,668.43 million rubles). It is recommended that this amount of

Table 1 Coverage of business with energy innovations and equipment wear and tear in energy and volume of investments in fixed assets in energy in the sampling regions in Russia in 2020

Region	*Investments in fixed assets in the provision of electric energy, gas and steam, as well as air conditioning, million rubles*	*Share of organizations implementing environmental innovations that contribute to the reduction of energy costs for the production of a unit of goods, works, services, %*	*Level of depreciation of fixed assets in the field of electric power, gas and steam supply, as well as air conditioning, %*
Moscow	114,166.9	56.7	46.6
St. Petersburg	45,230.0	50.0	42.7
Khanty-Mansi Autonomous Region—Ugra	21,133.7	50.0	50.1
Yamal-Nenets Autonomous Region	5,130.0	20.0	43.9
Kaliningrad Region	18,963.8	50.0	24.7
Tyumen region (without autonomous districts)	6,721.2	11.1	57.6
Novosibirsk Region	8,578.9	53.3	55.0
Sverdlovsk Region	20,416.7	55.6	37.5
Khabarovsk Territory	13,572.1	85.7	52.4
Republic of Tatarstan	12,771.0	66.7	35.9

Source Compiled by the authors on the basis of the materials of Federal State Statistics Service (2021)

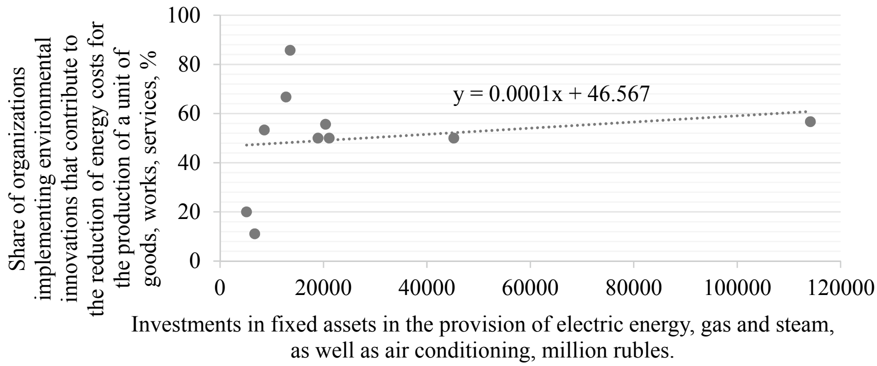

Fig. 2 Regression dependence of the coverage of the business with energy innovations on the volume of investments in fixed assets in the energy sector in the sampling regions in Russia in 2020 (*Source* Calculated and built by the authors)

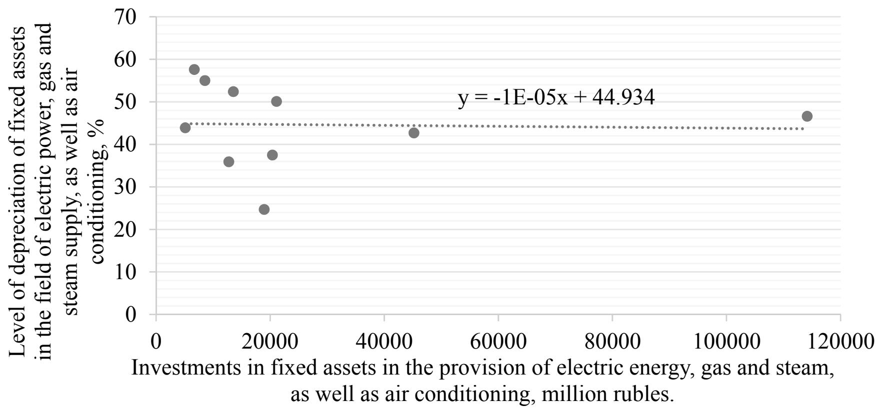

Fig. 3 Regression dependence of equipment wear in the energy sector on the volume of investments in fixed assets in the energy sector in the sampling regions in Russia in 2020 (*Source* Calculated and built by the authors)

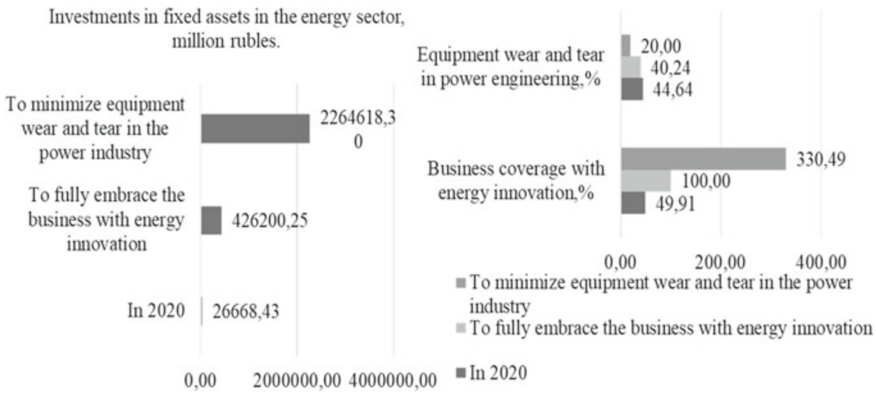

Fig. 4 The necessary amount of investment in fixed assets in the energy sector to achieve full coverage of the business with energy innovations and reduce wear and tear of equipment in the energy sector until 2030 (*Source* Calculated and built by the authors)

financing be laid down for the first stage (until 2024) of the financial strategy for the development of energy in the regions of Russia in industry 4.0 for the period until 2030 in order to achieve the goals of sustainable development and security. At this stage, equipment wear in the energy sector will be reduced to only 40.24% (compared to 44.64% in 2020).

In order to reduce equipment wear in the energy industry to normal (for the digital economy) The level (20%) at the second stage (until 2024) of the financial strategy for the development of energy in the regions of Russia in industry 4.0 for the period until 2030 in order to achieve the goals of sustainable development and security, it is recommended to increase the volume of investments in fixed assets in the energy sector to 2,264,618 million rubles. That is, 85 times compared to 2020. Thanks to this, the activity of introducing energy innovations in Russian entrepreneurship will triple.

5 Conclusion

Therefore, a financial strategy for the development of energy in the regions of Russia in the industry 4.0 for the period until 2030 was developed and scientifically justified in order to realize the goals of sustainable development and security. It was revealed that a severe shortage is a serious barrier to the digitalization of energy in the regions of Russia. At the first stage of implementation of the developed strategy (until 2024), it is recommended to increase the volume of investments in fixed assets in the energy sector by 16 times, and at the second stage (until 2030)—by 85 times compared to 2020.

Diversification of sources of financing of energy digitalization should play an important role in the practical implementation of the proposed financial strategy for the development of energy in the regions of Russia in the 4.0 industry for the period until 2030 in order to realize the goals of sustainable development and ensure security. Against the background of the pandemic and the economic crisis, COVID-19 Russian enterprises will not be able to place a sufficient amount of their own funds as investments in fixed assets. Therefore, large-scale funding from federal and regional budgets will be required.

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Mechanism of Implementation of "Green" Investment-Innovative Initiatives in "Smart" Production Under the Control of Artificial Intelligence in the Interests of Environmental Safety of the Region

Oleg G. Karpovich, Murat A. Bulgarov, Nelia A. Deberdeeva, and Evgeniy G. Abashin

1 Introduction

An urgent scientific and practical problem of our time is the gap between the interests of environmental security in the region, shared in the regional community and supported by public authorities in the region, and the interests of regional entrepreneurship, which imply an increase in profits in most cases through an increase in the environmental expenses of production. The increased difficulty in solving this problem lies in its contradiction, since in reality the private and public interests are in many ways similar, but, nevertheless, are implemented in different ways.

In the age of responsible consumption, there is ample room for additional profits from green investment and innovation initiatives. For many enterprises, corporate environmental responsibility is a prerequisite for survival in an aggressive market environment with high green competition. Many enterprises embrace and support sustainable development goals, especially in terms

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of environmental protection, but despite their incorporation into corporate reporting, business operations are not fully sustainable.

In this work, the hypothesis is that the root (true) reason for the problem is not in the divergence of private and public interests, but in the optimality of corporate governance (lack of control, opacity and complexity of management), because of which their own environmental guidelines for business development are not achieved in its economic activities. The problem can be solved by starting smart production, in which the control functions are automated and therefore performed more efficiently.

But not all advanced digital technologies contribute to increasing environmental responsibility of business, and it is necessary to select precisely those technologies that are important for the implementation of green investment and innovation initiatives. This work is aimed at selecting key described technologies in the regions of Russia and developing a mechanism for implementing "green" investment and innovation initiatives in smart production under the control of artificial intelligence in the interests of environmental safety in the region.

2 Literature Review

The theory and practice of implementing green investment innovation initiatives in modern entrepreneurship is described in Ghosh et al. (2020), Melander and Pazirandeh (2019), Shahzad et al. (2020), Skordoulis et al. (2020), Soewarno et al. (2019), Tariq et al. (2019a), (2019b). The organizational and managerial aspects of the launch and functioning of smart industries under the control of artificial intelligence are reflected in the works of Bogoviz (2020), Bogoviz et al. (2018), Ivanova and Smirnova (2019), Lobova and Bogoviz (2019), Popkova et al. (2021), Tskhadadze and Ioseliani (2019).

However, existing publications do not reveal issues at the intersection of smart and green industries, the isolation of which and the uncertainty of the prospects for their systemic implementation are a gap in the available scientific knowledge. To fill the identified gap in this work, a mechanism is being created to implement "green" investment-innovative initiatives in smart production under the control of artificial intelligence in the interests of environmental security in the region.

3 Materials and Method

This research is conducted on the example of all eight allocated federal districts of the Russian Federation based on data for 2020. To test the hypothesis, a correlation between technologies used in smart enterprises (from Table 1) and implemented "green" investment and innovation initiatives (from Table 2) is determined. This is done in order to select those green initiatives that are amenable to smart management, as well as to identify those technologies that contribute to the implementation of green initiatives.

Table 1 The share of organizations engaged in smart production in the regions of Russia in 2020, in terms of applied technologies, %

Federal district of the Russian Federation	*Broad Band WL*	*Cloud services*	*RFID-technologies*	*ERP-systems*
Central	87.4	25.8	5.3	15.4
Northwest	88.6	23.8	5.2	13.2
Southern	80.8	21.9	4.7	10.3
North Caucasus	80.3	22.2	3.5	5.8
Volga	83.5	20.5	4.8	12.6
Ural	82.9	24.1	6.0	14.5
Siberian	77.8	22.1	4.9	9.9
Far East	78.6	21.8	4.2	7.7

(*Source* Compiled by the authors based on materials of the Ministry of Digital Development, Communications and Mass Communications of the Russian Federation, Federal State Statistics Service, National Research University "Higher School of Economics" (2021))

Table 2 The share of organizations implementing "green" investment and innovation initiatives in the regions of Russia in 2020 in the context of the areas of ensuring environmental safety of production, %

Federal district of the Russian Federation	*Material cost reduction per unit of production*	*Reducing energy costs per unit of production*	*Carbon Dioxide emission reduction*	*Substituting raw materials and materials for safe or less hazardous*	*Reducing Pollution*	*Recycling waste, water or materials*
Central	44.5	54.5	35.6	33.3	68.7	38.9
Northwest	44.7	56.4	36.2	27.7	68.1	36.2
Southern	47.5	60.0	27.5	40.0	62.5	37.5
North Caucasus	54.5	90.9	27.3	36.4	36.4	27.3
Volga	39.8	51.1	30.6	32.3	70.4	34.9
Ural	41.5	43.4	35.8	17.0	69.8	43.4
Siberian	43.9	51.2	20.7	64.6	64.6	39.0
Far East	42.2	60.0	31.1	66.7	66.7	33.3

(*Source* Compiled by the authors based on the materials of Federal State Statistics Service (2021))

In order to clarify correlation relationships on selected technologies and initiatives, regression relationships are established, with the help of which key technologies and their development requirements are selected.

4 Results

In order to determine the technological support and the main directions of the mechanism for implementing "green" investment-innovative initiatives in smart production under the control of artificial intelligence in the interests of environmental safety in the region, refer to the results of correlation analysis of data from Tables 1 and 2 (Fig. 1).

Rice. 1 clearly demonstrated that the implementation of such "green" investment and innovation initiatives in the regions of Russia in 2020, such as reducing material costs for the production of a unit of products, reducing energy costs for the production of a unit of products and replacing raw materials and materials with safe or less dangerous ones, cannot be "smart" controlled, unlike initiatives such as reducing carbon dioxide emissions into the atmosphere (y_1), reducing environmental pollution (y_2) and recycling waste, water or materials (y_3).

At the same time, all the digital technologies under consideration are in demand and promising (at this preliminary stage of analysis). In order to clarify the relationships of the selected green initiatives, their regression dependence from all advanced technologies was determined (broadband Internet: x_1, cloud services: x_2, RFID technologies: x_3, ERP- systems: x_4), which allowed to obtain the following regression equations:

y_1 = -82.41 + 1.19x_1 + 0.36x_2 + 3.27x_3-0.78x_4, multiple correlation high (82.34%);
y_2 = 110.48–0.56x_1-2.46x_2 + 5.18x_3-2.69x_4, multiple correlation high (85.26%);

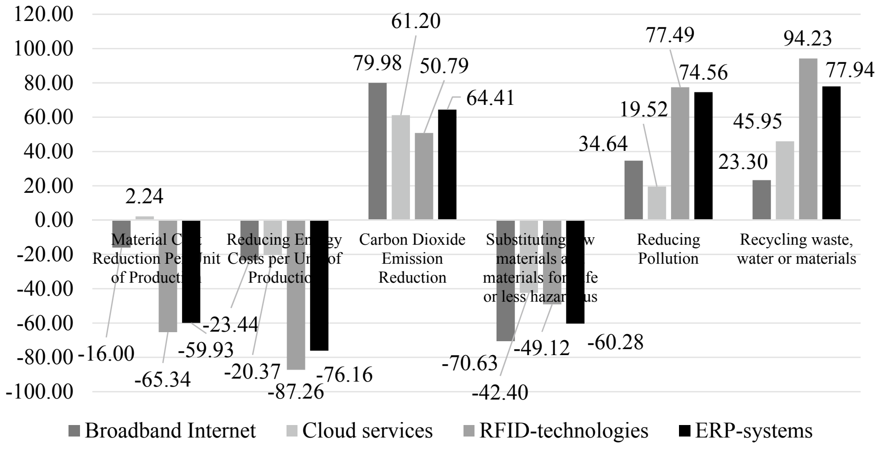

Fig. 1 Correlation between technologies used in "smart" enterprises and implemented "green" initiatives in the regions of Russia in 2020, % (*Source* Calculated and built by the authors)

$y_3 = 47.89–0.60x_1 + 0.32x_2 + 5.34x_3-0.45x_4$, multiple correlation high (98.72%).

As it can be seen, the factor variable x_3 was the only one with which all three dependent variables showed a positive regression relationship. Based on the regression equations obtained, it was established that the maximization (100%) of the share of organizations implementing all three selected "green" initiatives in the regions of Russia is achieved with an increase in the share of organizations using RFID technologies to 26.08% (+ 440.49% compared to 2020). Therefore, the use of RFID technologies is the basis of the proposed mechanism for implementing green investment and innovation initiatives in smart production under the control of artificial intelligence in the interests of environmental safety in the region (Fig. 2).

The mechanism presented in Fig. 2 showed that RFID technologies scan each business transaction in smart production at the enterprise. Artificial intelligence transmits, firstly, general information about all business operations of the enterprise in real time and, secondly, environmental characteristics of business operations of the enterprise.

Public administration bodies in the region convey to artificial intelligence the interests of environmental security of the region and dictate requirements for their compliance. According to this, artificial intelligence in smart production at the enterprise manages green investment and innovation initiatives

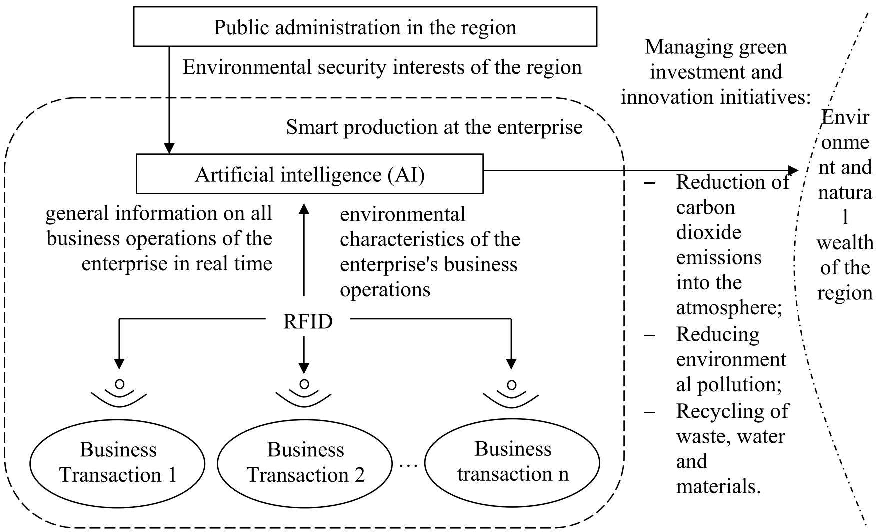

Fig. 2 Mechanism of implementation of "green" investment-innovative initiatives in "smart" production under the control of artificial intelligence in the interests of environmental safety of the region (*Source* Developed and built by the authors)

that reduce carbon dioxide emissions to the atmosphere, reduce environmental pollution and recycle waste, water and materials. This protects the environment and preserves the natural wealth of the region.

5 Conclusion

At the end of the research, we note that the developed mechanism for implementing "green" investment-innovative initiatives in smart production under the control of artificial intelligence in the interests of environmental security of the region takes into account the specifics of the regions of Russia. The results of the regression analysis have high scientific value and practical usefulness, since they showed that RFID technologies, the least common in the regions of Russia (used only 4.83% of enterprises, compared with, for example, broadband Internet used by 82.49% of enterprises), make a main contribution to ensuring the environmental security of the regional economy.

Based on regression models, it was found that only an increase in the prevalence of RFID technologies to 26.08% of enterprises (an increase of 6 times compared to 2020) is enough to ensure full coverage of enterprises in the regions of Russia with "green" investment and innovation initiatives. The conclusion is based on the developed mechanism for the implementation of "green" investment-innovative initiatives in smart production under the control of artificial intelligence in the interests of environmental security of the region. In future studies, it is necessary to find out whether the key role of RFID technologies in ensuring corporate environmental responsibility for regions of other countries is characteristic or this is a feature of the regions of Russia.

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Conclusion

The fight against climate change will continue. This second volume of the book "Climate Change in Industry 4.0" showed in what directions it should be carried out and how it should be organized. However, the future is uncertain, and in the context of the ongoing pandemic and the COVID-19 crisis, negative scenarios for the development of the global economy for the coming years prevail. In this regard, it is important to consider and strive to overcome the barriers to combating climate change in the economy of the future in the context of Industry 4.0.

Among the barriers is the persistent and even growing random distribution of environmental costs among economic systems. In this regard, in addition to socio-economic inequality, the ecological inequality of countries will be taken into account everywhere. Economic systems feel the pressure of climate change to varying degrees. In addition to this, although most of the world's countries are involved in the Fourth Industrial Revolution, digitalization is also uneven and occurs at different rates. In this regard, in the economy of the future, the countries of the world will have different opportunities and different interests in using the capabilities of Industry 4.0 to combat climate change. The digital and environmental inequality of countries in the economies can become a serious obstacle to a coherent international fight against climate change through Industry 4.0.

Another barrier, already obvious today, is associated with the fact that the fight against climate change in most cases is based not on the desire of business entities to protect the environment but on their desire to maximize their non-environmental benefits (for example, strengthening the reputation of a responsible producer or consumer or meeting the requirements of the state). Without the real interest of business entities in the fight against climate change in the economy of the future, this struggle based on Industry 4.0 will be formal, which is unacceptable. Therefore, it is important now to find a way to raise the level of environmental awareness of society and ensure recognition of

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the importance of universal priorities for sustainable development along with private commercial interests.

This book has emphasized and highlighted the identified barriers but they have yet to manifest themselves in the economy of the future, and it is advisable to devote further scientific research to their solution to the prospects of combating climate change in the context of Industry 4.0.

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