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Measuring the Contribution of the "Knowledge Economy" to the Economic Growth Rate: Comparative Analysis

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Abstract

The formation and development of the "knowledge economy" is an important characterization of the modern global world, and this process depends a lot from the development of education and science, which ensure the production and transfer of knowledge. In this regard, the dimension of the influence of this aggregated sector on the dynamics of the development of the economy as a whole is of importance. The purpose of the research is to determine the size of the sector "knowledge economy" in the European Union and some countries for comparison, as well as assess the contribution of this sector, measured by different methods in the rate of economic growth. The methodology of the study is a structural analysis, on the basis of which it becomes possible to single out the content of the "knowledge economy" sector and obtain a "structural formula" for assessing the contribution of this sector to the economic growth rate. The result of the application of this methodology was that it was possible to identify an overestimated estimate of the "knowledge economy" according to the Eurostat methodology, which takes into account the types of activities by the number of employees with a certain level of education, and the scale of the "knowledge economy" sector was comparable with the location of countries in terms of per capita income. Having considered the discussion regarding the experience of carrying out institutional reforms of education in the European Union, we come to the conclusion that the competence-based approach to basic education is limited in solving the problem of training personnel with higher education. The unreasonableness of institutional reforms that adjust education to the current tasks of the business, replacing the teacher with a computer, has a number of significant limitations that will not affect the measurement key, but can lead to a quality that will subsequently affect the rate of economic growth not upward.

Keywords "Knowledge economy" · Education · gross domestic product · European Union · "Structural formula" · Institutional reforms of education

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Introduction

Modern education operates in a new reality that is often referred to as the "knowledge economy" (Weber 2011; Saviotti et al. 2016), and this reality covers not only education but also other economic activities. Emerging new knowledge affects the emergence of innovation and economic growth. The conceptual basis of this study consists of numerous scientific papers in the field of "knowledge economy," but at the same time, they do not solve the question of measuring the contribution of the knowledge economy to the overall economic dynamics, including the comparative aspect by country. This statement is important because the knowledge economy develops in different ways and contributes to economic dynamics, thereby determining the difference in competitive advantages between countries. Let us list some recent works, highlighting the most significant areas in the application of research efforts. In the modern world, there is a transition from the standard concept of the knowledge economy, where knowledge is generated within and for production, to the concept of knowledge generated in the service sector and the creative industry (Švarc and Dabić 2017). In this study, we assume that there are activities that create, distribute, and use new knowledge; that is, we will consider the knowledge covered by both of these concepts. It should be noted that the question of measuring the knowledge economy and assessing its contribution to the overall economic dynamics remains open, since the existing approaches are either reduced to knowledge management tasks (Yu and Yang 2018), consider micro-level tasks, or are related to the assessment of the impact of knowledge on the functioning of firms or other agents of the economy. In particular, comparative studies on countries are conducted from this perspective.

In particular, research on the production and use of knowledge, as well as numerous studies on the impact of information and the functioning of information systems (Du and Dai 2018; Cram et al. 2016), usually address the microeconomic level (Al-Emran et al. 2018), for example, information security (Flowerday and Tuyikeze 2016) or patent production, which is influenced by the level of scientific training and collaboration (Acosta et al. 2020). Most of the research has a general focus on information or knowledge management (Kianto et al. 2017; Breznik 2018; Costa et al. 2016) or its expert application (Temel and Karimov 2019).

However, macroeconomic assessments of the impact of the "knowledge economy" on economic growth, together with questions of knowledge management at firms and corporations, or their impact on innovation and productivity (Shujahat et al. 2019), are of high significance in terms of developing enabling policies and measuring the impact of institutional reforms on the transformation of education and science as the two driving engines of the "knowledge economy." In addition, there are researches on elucidating the informational circumstances of growth, linking information about the environment with growth by evolutionary equations (Hilbert 2016). The possibility of such modeling is the result of accumulated knowledge, including in the field of methods for modeling various scenario situations.

It should be noted that according to the literature, structural and empirical studies with macroeconomic consequences are less extensive, especially those related to the assessment of the impact of the "knowledge economy" on economic dynamics. Here, the method of measuring the "knowledge economy" as an aggregated sector, as well as a more or less accurate assessment of the contribution of this sector to the growth rate,

is crucial. Both tasks have a self-sufficient significance and constitute the purpose of the research of this article. Moreover, the search for a solution is directed to the practical assessment of the "knowledge economy" based on the Eurostat methodology, with the identification of its other capabilities and author's proposals, as well as the assessment of the contribution to the growth rate according to the author's proposed method. The knowledge economy has its own characteristics in each country and contributes to the pace of economic development. This research is devoted to the solution of this problem—measuring the size and contribution to the growth rate of the knowledge economy, as well as the impact of institutional reforms in education as a factor in changing the knowledge economy.

Characteristics of quantitate changes in the education system as a system-forming industry are given by institutional reforms that are in the initial stage and that are not too late to adjust in order to improve the effectiveness of education. The purpose of the study is to determine the scale of the "knowledge economy" in a comparative aspect for the European Union's countries and to determine the contribution of the aggregated sector to the country's economic growth rate. In addition, the final section of the study is devoted to the analysis of current institutional changes in education as the central activity of the knowledge economy. Let us compare the size of the knowledge economy for the European Union, its individual countries Germany and Spain (selected at random) and Russia, and conduct a comparative analysis of the contribution of the knowledge economy to the growth rate of countries. For this purpose, we will perform the necessary calculations according to the structural formula for assessing the contribution of the knowledge economy to the growth rate, using the method of paired correlations, and perform a comparative analysis of the contribution to the growth rate of the knowledge economy for these countries. The theoretical basis of the study is a structural analysis of economic growth, which allows to expand the possibilities of assessing the knowledge economy as a sector, which is carried out by Eurostat, due to the author's methodology for such an assessment. In addition, the methodology allows us to measure the contribution of the "knowledge economy" to the growth rate, thereby creating a basis for comparative research on the development of the knowledge economy in different countries. This statement of the problem is relevant, since it allows us to identify, in addition to the scale of the "knowledge economy" as a sector, the conditions for its development and the impact on the economy as a whole, including dynamics. This is useful in determining the prospects for the "knowledge economy" and evaluating institutional changes in science and education aimed at improving the quality of these activities.

"Knowledge Economy" in the Modern World: Approaches to Measuring the Sector

The "knowledge economy" represents a promising direction for the development of the modern world, becoming a symbol of the progressive movement (Porrini and Starbuck 2015). The volume and complexity of transactions are increasing, and the impact of transactional activities on economic development and current growth rates exceeds the impact of manufacturing sectors that were dominant thirty years ago. Changes in knowledge and technology occur at a high rate, which cannot be ignored in assessing

the impact of these activities on economic growth and transformation (Alonso-Carrera and Raurich 2018; Samaniego and Sun 2016). Of course, quantitative estimates are directed to the current dynamics; it does not allow to take into account the qualitative changes that transform the functions and institutions of the modern world, which is associated with changes in the forms and content of education that can modify human capital and various types of work (Alonso-Carrera and Raurich 2018).

Knowledge, on the one hand, cannot but influence the emergence of innovators who create new concepts, ideas, products, services, processes, methods, technologies, and manage new projects[1]. However, on the other hand, the emergence of an innovator (Schumpeter 2008; Hanusch and Pyka 2017; Saviotti et al. 2016) is also possible from a conservative[2] due to his retraining or providing the necessary resources for the development of his ideas, which have not yet been applied, but which he had. In this sense, we can talk about the contribution to the quality of innovation dynamics of the past organization of education and current economic policies that allow us to encourage such a transition (from conservatives to innovators) (Saviotti et al. 2016; Mohamad 2014). Thus, knowledge is distributed between innovators and conservatives, and changes in this structure of agents affect the further evolution of the economy.

Excellence in knowledge has long been a competitive advantage. However, progress in knowledge has led to the fact that they have become a separate product; there are types of activities that produce, replicate, and store, which together can be described as an aggregated sector that is part of the economy or as a "knowledge economy."

In contrast to information, knowledge represents obtained (by scientific methods), well-structured relevant information, ready for repeated use and use to build up new knowledge and improve old knowledge. However, the formation of knowledge markets, since knowledge is a highly differentiated product, has a number of difficulties, for example, with the establishment of prices. To a large extent, there is the effect of information asymmetry, negative selection, associated, inter alia, with the obsolescence of knowledge. Moreover, this process, depending on the creation of new knowledge, may not be determined by it. Thus, the market price does not at all reflect the true value of knowledge, which sharply rises or falls over time. The knowledge that turns into technological capabilities is of particular interest to the business. A fierce competition is unfolding for such knowledge and its carriers, which is reflected in the dynamics of investment in R&D (Vo and Le 2017; Kianto et al. 2017).

Thus, from how the system for obtaining new knowledge (science) is organized, what initial groundwork and areas of work existed, how it takes advantage of the globalization of scientific knowledge[3], and the state of schools and the educational system, including the university one, to a certain extent depends on what knowledge will be created. In addition, it depends on how competitive it will be and what technological capabilities it can be turned into. The last stage also depends on the

[1] Source: World Bank https://data.worldbank.org/indicator/NY.GDP.MKTP.KD https://data.oecd.org/rd/researchers.htm.

[2] A conservative is an economic agent engaged in activities of the opposite direction, or an innovator. It is aimed at existing products, markets, services, technologies, methods, processes, projects in the case that can only slightly improve them, but does not create completely new listed objects.

[3] The effect of the globalization of scientific knowledge is understood as its dissemination with the lowest transaction costs due to scientific communication and the ability to quickly build up knowledge in some areas, having received relevant information about the research.

current state of the objects of use of knowledge and especially technological knowledge—on industry, agriculture, and various types of business, including the information sector.

Taking into account the effects of the long-term impact of the "knowledge economy" will be useful, although difficult, since knowledge has inherent uncertainty. In order to carry out such complex assessments (they are not included in the objectives of this research), we first need to outline the scale of such a sector as the "knowledge economy," finding out its effect on the current dynamics of the economy. The problem of measuring and evaluating the contribution to the growth rate for any economic sector or activity is an independent task, the solution of which will be carried out below.

The available research on measuring the knowledge economy is mainly concerned with entering certain indicators that characterize the knowledge economy and establishing correlations between them, such as domestic research and development expenditures, the number of researchers, the growth rate of gross domestic product, GDP per capita, the human development index (HDI), and overall factor productivity (Mêgnigbêto 2018). However, these parameters immediately characterize the economic dynamics, and those that can be interpreted as characteristics of the knowledge economy in reality are only an assessment of a certain segment of the knowledge economy, without providing an assessment of it as an economic sector.

From the author's point of view of measuring the impact of the "knowledge economy" on the development of the modern economy, the following areas of analytical work seem valuable:

- the formation of the sector "knowledge economy", which includes various activities related to the production, replication, transfer, and knowledge management;
- determination of the share of the "knowledge economy" in GDP, as well as the contribution to the country's economic growth rate;
- assessment of the impact of knowledge on technological development, innovation, and the functioning of the education system;
- clarification of institutions that contribute to the most effective development of education and science, the emergence, replication, and application of knowledge.

Based on the above positions, it can be seen that quantitative measurements of the impact of the "knowledge economy" on economic development suggest the allocation of activities that should be attributed to the sector of the "knowledge economy," the summation of these activities, and obtaining the total gross value added (further—GVA) created by the "knowledge economy." When the contours of the "knowledge economy," thanks to the indicated actions, become more or less clear, then it is possible, using structural analysis, to highlight the contribution of this aggregate knowledge sector to the country's economic growth rate.

Thus, it is of significant importance the assessment of the "knowledge economy" scale in country and the dynamism of its development, including the impact on the overall economic dynamics (growth rate).

The selection of activities related to the "knowledge economy" is carried out normatively, and the added value associated with the creation, application or duplication of knowledge, or its market value, is the measurement criterion. However, it is the normative nature of the allocation and the inherent errors of the applied criteria that are

the objective limitation of an accurate assessment. Usually, in the established practice, two basic approaches are applied to the solution of the indicated measurement problems, for which certain disadvantages are inherent.

Firstly, the standard Eurostat methodology is used[4]. Its limitation is the accounting of those activities that are not directly related to the production, replication of knowledge. This applies to the sector of services in the field of mining, as well as the production of coke and petroleum products, financial services, and others. This method involves accounting for various types of activities of employed personnel with a certain type of education. Moreover, the number of people with this type of education at the accounting facility should exceed the established standard (33%) of the total number of people employed at the facility. According to the Eurostat methodology[5], an activity is considered knowledge-intensive if in the total number of people employed in this type of activity more than 33% are employees of levels 5–8 by the International Standard Classification of Education (ISCED, 2011)[6]. Moreover, industry or services are not allocated here, and the assessment is carried out according to two aggregate indicators for all industries at once: (1) knowledge-intensive activities—KIA and (2) knowledge-intensive activities business industries—KIABI.

Knowledge-intensive activities according to Eurostat include mining support service activities; manufacture of coke and refined petroleum products; manufacture of basic pharmaceutical products and pharmaceutical preparations; manufacture of computer, electronic and optical products, air transport, publishing activities, motion picture, video and television program production and pharmaceutical preparations, programming and broadcasting activities, telecommunications, computer programming, consultancy and related activities, information service activities, financial service activities, except insurance and pension funding, insurance, reinsurance, and pension funding, except compulsory social security, activities auxiliary to financial services, and insurance activities, legal and accounting activities, activities of head offices; management consultancy activities, and architectural and engineering activities; technical testing and analysis, scientific research and development, advertising and market research, other professional, scientific and technical activities, veterinary activities, employment activities, travel agency, tour operator reservation service and related activities, public administration and defense; and compulsory social security, education, human health activities, creative, arts and entertainment activities, libraries, archives, museums and other cultural activities, activities of membership organizations, activities of extraterritorial organizations and bodies. Assessment of these activities is carried out according to the number of people employed in them with a certain level of education according to the ISCED.

As we can see, the wide range of activities is taken into account when calculating the scale of the "knowledge economy" in the product being created. The disadvantage of this method is that it includes activities that are not directly related to the production, replication of knowledge, and, moreover, the formation of added value of knowledge in these types of activities may not have a decisive influence, as in the production of coke

[4] Eurostat: https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an8.pdf.
[5] Ibid, p. 3-4.
[6] ISCED: http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf (ISCED level 5—short-cycle tertiary education, 6—bachelor's or equivalent level, 7—master's or equivalent level, 8—doctoral or equivalent level).

and petroleum products. In addition, an assessment by the formal criterion of what kind of education person received in the diploma does not take into account the quality of this education, but it determines the extent of knowledge possession and use. Thus, the applied method of statistical accounting is formally quantitative, giving an overestimated estimate of the "knowledge economy,"

Secondly, the method of measuring the value of the cost of producing knowledge or the market value of knowledge is also not without drawbacks, since cost accounting can lead to the fact that costs that are not related to the production and replication of knowledge (for example, R&D that are not gave a positive result[7]). The method of accounting for knowledge at their market value has no less disadvantage than the method of accounting for costs. For certain types of knowledge, for example, obtained in the course of basic research, there is no current demand; therefore, it is not possible to give a market assessment. Moreover, this assessment may arise much later due to the effect of the "deferred value" of knowledge. Moreover, the effect is able to manifest itself, if knowledge experiences an increase in application over time, but may not occur if knowledge quickly becomes obsolete and is replaced by other more valuable knowledge.

Thus, on the one hand, the established tradition of statistical accounting of the "knowledge economy" works to increase the share of this aggregated sector in the economy. On the other hand, the existing and practiced methods for assessing knowledge, which are known and have been used in one way or another in a large number of studies on costs and market value, have inaccuracies that are associated with the object of study—knowledge.

In connection with the above, given the shortcomings of various methods of accounting for knowledge, the current assessment of knowledge can be carried out at added value, especially in the types of activities responsible for the production of new and use of existing knowledge, as well as its replication. We are talking about those activities that are directly responsible for the creation and use of knowledge, work with information and the creation of appropriate equipment. These types of activities, in our opinion, include research and development; education; professional, scientific, technical, and other activities; employment and staffing activities; health and social services activities; creative activities in the field of art and the organization of entertainment, libraries, archives, museums and other cultural objects; activities in the field of architecture and engineering design; technical testing, research and analysis; computer software development, consulting services in this area and other related services; information technology activities; telecommunications activities; the production of films, videos and television programs, the publication of sound recordings and notes; television and radio broadcasting activities; production of machinery and equipment; production of electrical equipment; and manufacture of computers, electronic and optical products; production of medicines and materials used for medical purposes[8]. This assessment of the "knowledge economy" (in terms of GVA) seems to us to be a "narrow estimate"; it will give a smaller share of knowledge in the gross domestic

[7] Although many researchers believe that in science, a negative result is also an important result.

[8] Source: these types of activities were selected according to Eurostat https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do Further for calculations GVA is reduced to 2010 prices using the GDP deflator. The sum of the indicated types of activities on added value makes up the aggregated sector of the 'knowledge economy'.

product of the country. The assessment of the "knowledge economy" by the employed, that is, the knowledge holders with a certain level of education by a wide range of activities, can be considered a "broad assessment." Thus, a methodology for a pure assessment of the "knowledge economy" as an aggregated sector is proposed here.

The so-called "narrow assessment" of the GVA created in the types of activities responsible for the reproduction and transfer of knowledge can be even more tightened if the accounting for activities is limited only to, say, science and education with the addition (or not addition) of an activity, responsible for working with information.

Thus, as we see from the analysis, there is a problem of measuring the economy of knowledge and knowledge as such, which introduces the ambiguity of assessments of the development of these types of activities and their impact on the entire economy. If the scale of the types of activity does not correspond to the estimates, then the assessment of the contribution to the economic dynamics of the generated knowledge will naturally also differ. In addition, in relation to knowledge, there is the effect of strengthening or weakening their impact on economic development over time. This effect is poorly studied, since little data has been accumulated on how the synergetic in the field of knowledge work over time.

The issue of economic growth has always been central to economic discussions. In this connection, the influence of knowledge on growth and their current assessment of the dynamics of GDP is an important task. The created knowledge and a greater number of educated people give a positive external effect, expanding the possibilities of development. By the way, the current economic dynamics can be very modest. However, technological renewal, which becomes a derivative of accumulated knowledge, is a powerful factor in future economic growth, including through the creation of new competitive opportunities in world markets.

Next, we estimate the value of GDP and the current contribution of the "knowledge economy" sector to the economic growth rate of the European Union, and to compare the countries of Germany, Spain, and Russia. Firstly, we present the "structural formula" (Sukharev 2020) to conduct appropriate quantitative assessments; then we analyze the results. We will use the Eurostat methodology, as well as the author's narrow version of the assessment of the "knowledge economy," where education and science are considered as two main locomotives in the movement of the "knowledge economy."

The Size and Contribution of the Knowledge Economy Sector to the Development of the European Union and Russia

Let us estimate the contribution of the "knowledge economy" to the rate of economic growth using the structural formula, which obtain by distinguishing two sectors in the gross domestic product that add up to GDP, namely, the "knowledge economy" sector and the non-knowledge sector, which denote as a sector of other activities.

We will carry out the necessary calculations according to the Eurostat methodology and then according to the author's methodology for assessing the net value of the "knowledge economy" sector (described above) for the European Union, and for comparison for Germany and Spain (the results in the Figs. 1 and 2, the average estimates are placed in Table 1). The total value (Y) of GVA (equal to the country's

GDP) is representable in two parts: firstly, the GVA of the types of activities, which in total are given by the "knowledge economy" sector (Y_k), and secondly, the GVA of other activities (Y_a).

Then we can write that $Y = Y_k + Y_a$. Differentiating the time value of GVA and transforming the expression, we get the structural formula, which allows to estimate the economic growth rate and the contribution of the parts of the GVA to this rate.

The structural formula takes the form

$$g = g_k{*}k + g_a{*}a \tag{1}$$

where:

$g = \frac{1}{Y} * \frac{dY}{dt}$ is the growth rate of total GVA equal to GDP;

$g_k = \frac{1}{Y_k} * \frac{dY_k}{dt}$ and $g_a = \frac{1}{Y_a} * \frac{dY_a}{dt}$ are growth rates of the "knowledge economy" sector and the "other economy" sector respectively;

k and a are shares of the "knowledge economy" and "other economy," respectively.

Thus, the structural formula shows that the multiplication of the growth rate of each of the two parts of the economy and its share in GVA in total will give the value of the

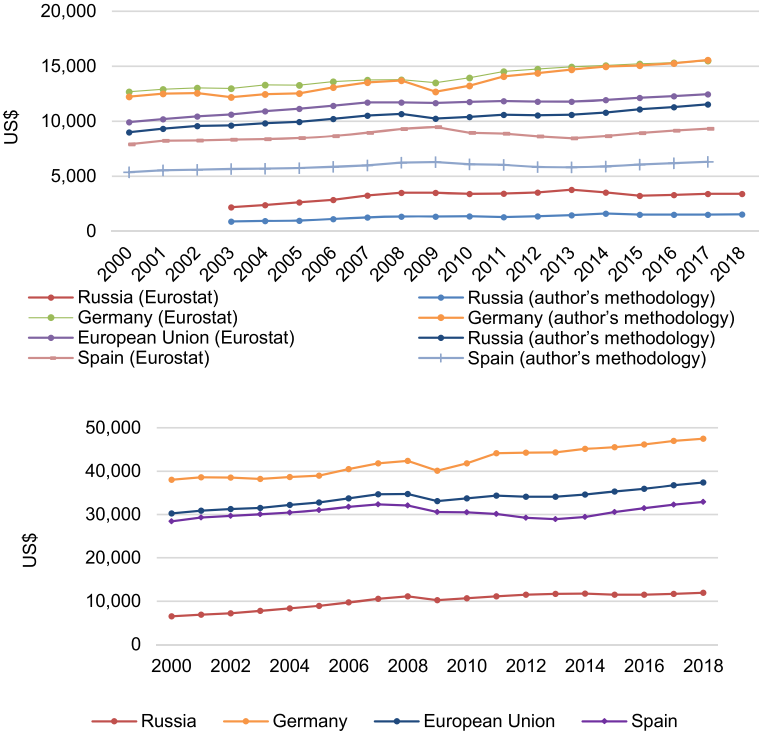

Fig. 1 GVA of the "knowledge economy" per capita according to the Eurostat methodology and the author's approach (above), GDP per capita (below), in 2010 prices (Source: calculation made according to the World Bank https://data.worldbank.org/indicator/NY.GDP.PCAP. CD?view=chart, https://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG?view=chart; Rosstat https://www.gks.ru/ accounts; Eurostat https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.)

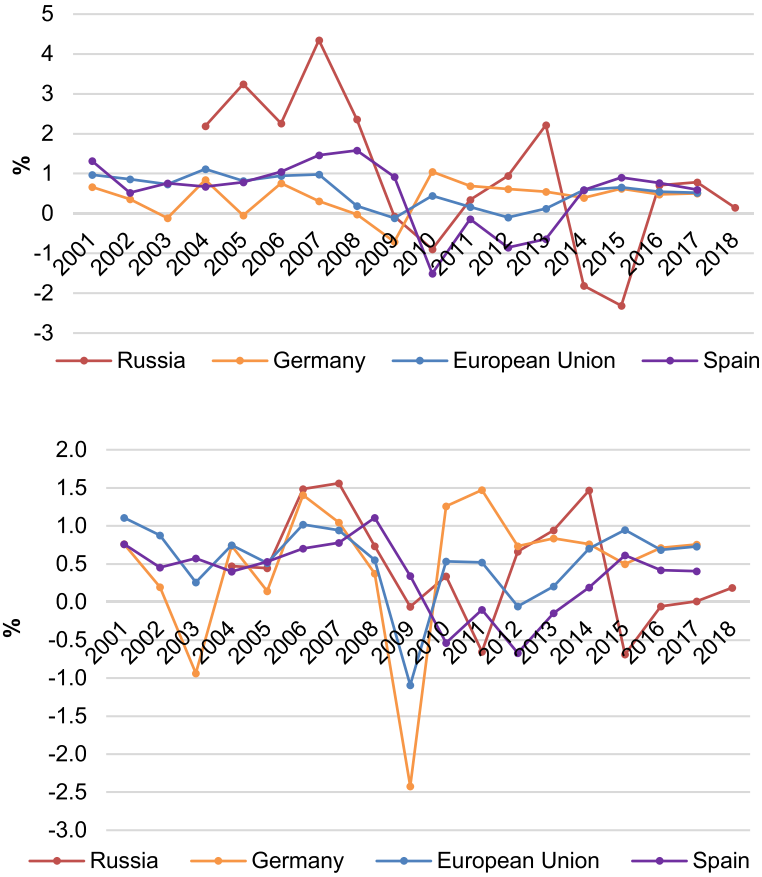

Fig. 2 Assessment of the contribution to the growth rate of the "knowledge economy" of countries according to the Eurostat methodology (above) and the author's methodology (below)

country's economic growth rate. The multiplication of the growth rate of the aggregated part of the economy and the share of this part represents a contribution to the rate of economic growth.

Thus, using this approach, it seems possible to evaluate the scale of the "knowledge economy" and the impact of its dynamics on economic development as a whole.

Next, let us present for these countries the calculation of the value of the "knowledge economy" according to the GVA in 2010 prices in the European Union, Germany, Spain, and Russia. Then we will calculate the contribution to the growth rate and compare the Eurostat methodology and the author's methodology for measuring the "knowledge economy" in a "narrow sense." The average total calculation result for the period 2003–2017 was placed in Table 1 (taken the total period for all compared countries).

From Fig. 1 you can see that the author's methodology gives a smaller absolute value of the "knowledge economy" compared with the Eurostat methodology, which is broader, since it includes activities based on the number of educated ones that are not directly related to the "knowledge economy." It should be noted that the location of the countries examined in the largest "knowledge economy" in descending order are

Table 1 Average estimate of the "knowledge economy" and its contribution to the growth rate of the European Union, Germany, Spain and Russia, 2003–2017 (The time period is limited to 2017, since Eurostat does not provide information for 2018, which is necessary for calculating the assessment parameters of the "knowledge economy." In Russia these data are provided since 2003 and are present for 2018. So that all countries can be compared in terms of their contribution to the growth rate of the "knowledge economy," a single time interval of 2003–2017 was taken for countries.)

	The average share of the "knowledge economy" in GDP,%, for the period		The average contribution of the "knowledge economy" to the GDP growth rate, %, for the period	
	Eurostat methodology	Author's methodology	Eurostat methodology	Author's methodology
European Union	34.3	30.9	0.51	0.48
Germany	33.4	32.5	0.39	0.49
Spain	28.8	19.5	0.46	0.31
Russia	30.3	12.3	1.02	0.48

Germany, the European Union, Spain, and Russia. According to Fig. 1 there is an equivalent arrangement of countries in terms of GDP per capita in 2010 prices. Spain is close in terms of GDP to this indicator for the EU, but the gap in knowledge economies is slightly larger. A country with less GDP per capita has a smaller "knowledge economy." The average share of the "knowledge economy" over the period, as well as the average contribution to the growth rate, is shown in Table 1. According to the Eurostat methodology, the largest share of the "knowledge economy" is typical for the EU; the contribution to the growth rate is the same. The share of the "knowledge economy" is close to the EU in Germany, but the contribution to the growth rate is less (Fig. 2). The calculation of the contributions of the "knowledge economy," estimated by two methods, to the growth rate is shown in Fig. 2 (above according to the Eurostat method, below according to the author's method). Table 1 contains the average contribution for the period.

From Fig. 2 and Table 1 it follows that the "knowledge economy" is developing at a slower pace for this set of activities considered by Eurostat. However, according to the Eurostat methodology, Russia has a high share of the "knowledge economy" and its contribution to the growth rate. It can be assumed that this is due precisely to the fact that the types of activities in which the share of the educated population, including the raw materials, are high, are taken into account. According to this methodology, Spain has a smaller share of the "knowledge economy" than the EU and Germany, but a higher contribution to the growth rate than Germany, which indicates a higher growth rate of this sector than in Germany. A completely different section of the estimates and the share of the "knowledge economy" and its contribution to the growth rate are provided by the use of the author's methodology, which allows one to take into account the "knowledge economy" in its purest form (Table 1).

Thus, the share of the "knowledge economy" for the countries under consideration is lower; however, for Spain it is almost 1.5 times lower; for Russia it is more than 2 times lower. This indicates a very high estimate of the "knowledge economy" for the educated population for these countries (Eurostat methodology), and the types of

activities of "knowledge economy" are developed much weaker and have a smaller scale. The average contribution of the "knowledge economy" to the growth rate of Spain and especially Russia is also significantly reduced. With a decrease in the share of the "knowledge economy" by the author's methodology, the contribution to the growth rate in Germany increases, which can be attributed to the fact that the types of activities directly related to the "knowledge economy," is developing very intensively (accounting for other types of activity is not taken into account). Thus, it can be seen that Spain and Russia, having a smaller share of the "knowledge economy," demonstrate a comparable contribution to their growth rate with the EU and Germany, which indicates a greater intensity of development of the "knowledge economy" in these countries.

As can be seen from Fig. 2 (above), in the crisis year of 2009, the decline in the contribution of the "knowledge economy" to the growth rate shifted by 2010 for Russia and Spain is not significant (it is not significant relative to the negative contribution of other activities in 2009 for these same countries), with the exception of Russia, when calculating according to the Eurostat methodology. The explanation for this is that the methodology includes a wide range of activities, which smooths the decline. According to the author's methodology (Fig. 2, below), all countries have either a negative contribution or a sharp decrease in the contribution of the "knowledge economy" in 2009. It is important to note that only in the Russian economy in 2015 and 2016, this contribution is negative, exceeding the negative contribution of the "knowledge economy" to the growth rate in Spain in 2010 that is the largest among the countries examined both by the Eurostat methodology (Fig. 2, above) and by the author's methodology (Fig. 2, below). If according to the Eurostat methodology in 2017, the contribution to the growth rate of the "knowledge economy" in Russia is comparable with the countries under consideration, then, using a more rigorous assessment, this contribution is significantly lower (Fig. 2, below). This is due to the fact that the types of activities directly representing the "knowledge economy" had worse dynamics than follows from the accounting for the types of activities carried out by educated personnel. The accuracy of the assessment of the knowledge economy contribution to the growth rate of the countries under consideration is given in Figs. 3 and 4, which confirm a high degree of coincidence between the fact and the calculation. This justifies the adequacy of the applied structural formula and the author's methodology for measuring the knowledge economy and its contribution to the growth rate.

No matter what share in the GDP, and no matter how fast the "knowledge economy" possesses, it creates the conditions for the emergence of innovators (Schumpeter 2008; Hanusch and Pyka 2017; Sukharev 2020). Therefore, the dynamics of these agents can be used to judge how the process of development of new industries and technologies is going on, that is, how new knowledge is used. It is also a peculiar characteristic of the development of the "knowledge economy" that affects the dynamics of high-tech industries.

The application of the method of pair correlations to establish the influence of the contribution of the "knowledge economy," and other activities on the economic growth rate are reflected in Tables 2, 3, 4, and 5. The analysis of these tables allows to conclude that there is a close connection between the contribution of the aggregated knowledge sector and growth, as well as a close connection between the contribution of the "knowledge economy" and the contribution of other activities to the rate of economic growth.

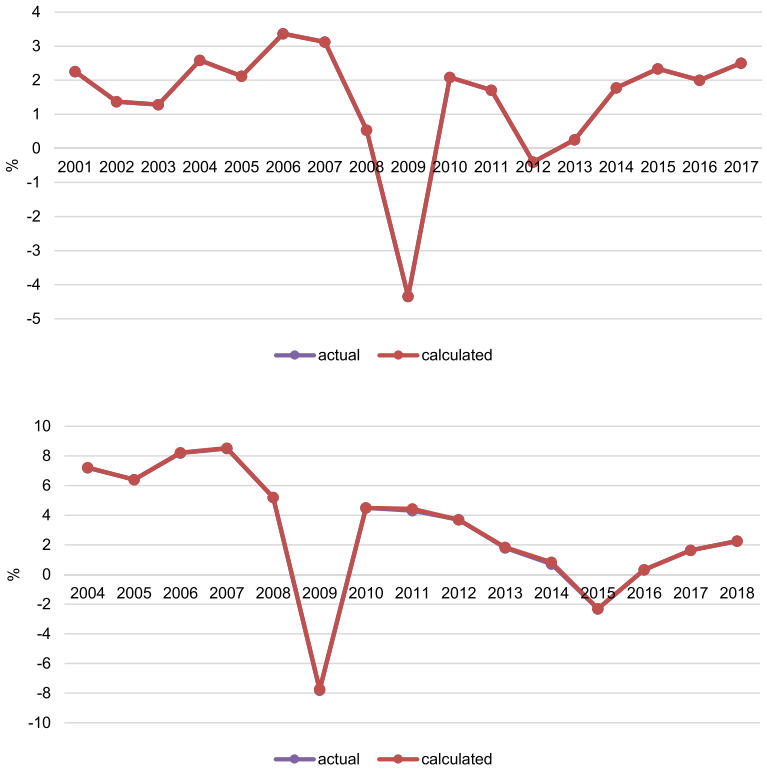

Fig. 3 Calculation accuracy of European Union (above) and Russia (below), 2001–2018

For the European Union (Table 2), the relationship between contributions to the growth rate of the two sectors examined is quite high and their influence on the growth rate is high. Germany closely repeats the relationship characteristic of the EU (Table 3); however, the relationship between the contribution of the "knowledge economy" and other activities ("non-knowledge economy") is significantly lower than for the EU. In Spain, the influence of the contribution of the "knowledge economy" on the growth rate is much lower than in Germany, but there is practically no correlation between the contributions of the two sectors (correlation coefficient 0.49; Table 4). Consequently, the "knowledge economy" in Spain has less impact on economic dynamics and is less associated with other sectors than in Germany and the EU. However, Russia shows the worst situation when the contribution of the "knowledge economy" and the contribution of the "non-knowledge economy" are practically unrelated (correlation 0.37), the relationship between the contribution of the "knowledge economy" and growth rate (0.51) is the lowest of the considered countries, and the contribution of other activities is related to growth rate that is similar to the contribution of the countries reviewed.

The analysis of pair correlations is an important tool for conducting a comparative effect of the "knowledge economy" on economic dynamics. It leads to an unambiguous conclusion that the low share of the "knowledge economy" and the lack of determination of the contributions of the "knowledge economy" and "non-knowledge economy"

Fig. 4 Calculation accuracy of Germany (above) and Spain (below), 2001–2018

sectors indicate difficulties not only in the development of the knowledge sector but also about broken links with other activities, low use of knowledge in them. It can be assumed that institutional transformation, in particular education, may in some way influence the nature of such ties. In this regard, at the final stage of the study, we consider the problem of institutional reforms of education in the European Union in a general conceptual setting.

Table 2 The tightness of the relationship between the contribution of sectors and growth in European Union, 2004–2017

European Union	The contribution of the "knowledge economy" to GDP	Contribution of "non-knowledge economy" to GDP	GDP growth rate
The contribution of the "knowledge economy" to GDP	1.00	0.95	0.97
Contribution of "non-knowledge economy" to GDP	0.95	1.00	1.00
GDP growth rate	0.97	1.00	1.00

Table 3 The tightness of the relationship between the contribution of sectors and growth in Germany, 2004–2017

Germany	The contribution of the "knowledge economy" to GDP	Contribution of "non-knowledge economy" to GDP	GDP growth rate
The contribution of the "knowledge economy" to GDP	1.00	0.88	0.95
Contribution of "non-knowledge economy" to GDP	0.88	1.00	0.98
GDP growth rate	0.95	0.98	1.00

Institutional Educational Reforms in Europe: Discussion

Education as a type of activity occupies a major place in the "knowledge economy," as it provides replication and transfer of knowledge, training of personnel of various qualifications and professional affiliations. Back in a long study by Datta and Nugent (1986) have shown that an increase in some professional group (lawyers) in the workforce can either positively or negatively affect the rate of economic growth. In particular, a 1% increase in the share of lawyers in the US workforce slowed growth by 1.08%. This study allows to pose the problem broader—how each of the professional groups and the change in its quantitative size and quality of training (education) will affect the economic dynamics. Here, the solution of such a problem was not part of the research purpose, however, to formulate such a task seems to be useful for future research. The reason is that with a positive result, you can get a kind of map of the influence of the professional structure on the economic growth of the country and, thereby, assuming changes in the education system, focus on the influence of the formed structure of labor on economic growth.

The idea was that the activity of lawyers increases transactions and the number of lawsuits of firms against each other increases, which reduces profits and inhibits investments with the ensuing inhibition and economic growth. This explanation deserves attention to consider the impact of the "knowledge economy" on economic growth, since this sector contains mainly transactional activities. Significant regulation of this sector, including the expansion of legal rules and procedures, can also reduce the degree of influence on the rate of economic growth. Also, the change of rules and the implementation of institutional reforms of education affect further economic

Table 4 The tightness of the relationship between the contribution of sectors and growth in Spain, 2004–2017

Spain	The contribution of the "knowledge economy" to GDP	Contribution of "non-knowledge economy" to GDP	GDP growth rate
The contribution of the "knowledge economy" to GDP	1.00	0.49	0.62
Contribution of "non-knowledge economy" to GDP	0.49	1.00	0.99
GDP growth rate	0.62	0.99	1.00

Table 5 The tightness of the relationship between the contribution of sectors and growth in Russia, 2004–2017

Russia	The contribution of the "knowledge economy" to GDP	Contribution of "non-knowledge economy" to GDP	GDP growth rate
The contribution of the "knowledge economy" to GDP	1.00	0.37	0.51
Contribution of "non-knowledge economy" to GDP	0.37	1.00	0.99
GDP growth rate	0.51	0.99	1.00

development not only in terms of pace but also in terms of quality characteristics and the ability to build up and disseminate knowledge.

For this reason, changes in education as the basic sector of the "knowledge economy" should be justified, including from the point of view of providing a contribution to the overall dynamics of development, as well as to obtain the desired quality.

The standardization and unification of education, the introduction of new rules, and the change in teaching methods cannot but affect the effectiveness of the dissemination, perception, and use of knowledge. Of course, these institutional influences also affect the process of creating knowledge, because they strongly affect students who will continue to create knowledge. In the European Union, in connection with these circumstances and the fact that the "knowledge economy" determines the nature of economic development, discussions on the institutional reorganization of education have become noticeable. So, in Germany, the problem of the crisis of education is being discussed[9]. According to the OECD report, the level of education in Germany fell below the average for European countries. The main reason that reduces to the implementation of institutional reforms in education, expressed in the formalization of its content, is also called. In this regard, the impact of such transactional changes that do not give greater opportunities for the transfer of knowledge and their improvement, the effectiveness of education is reduced, and at the same time, the impact on economic growth is reduced. Costs increase, including adaptation to new institutional changes; quality decreases; and investment and economic growth are ultimately hindered, including due to imbalances in the labor market. Institutional reforms come down to the need to form certain competencies supposedly necessary for business, instead of obtaining basic knowledge. Thus, the education system adapts to the needs and requirements of the business, but is it so good at managing to recognize the need for the necessary competencies. In addition, the adaptation costs of the system are not explicitly taken into account when translating it to other criteria and forms of functioning, because this mainly concerns the one who teaches. Ultimately, it is precisely his capabilities that determine the transfer of knowledge and skills to those who are learning. However, the transfer of knowledge and skills is only a part of the matter, since the second part of the training and application of knowledge takes place at the

[9] OECD, Education at a Glance 2018: OECD Indicators, OECD Publishing, Paris. URL: https://doi.org/10.1787/eag-2018-en https://www.vestifinance.ru/articles/127510.

workplace. This process is entirely dependent on the business—the needs and desire to improve staff. At the same time, in the process of labor, competencies may become obsolete or may require updating, and within the framework of a given business this cannot always be achieved with great success, since according to new institutes the student has not already received basic knowledge, but some competencies have been formed for him. On this occasion, the main discussion is underway, in particular in Germany, the general content of which can be indicated by the following two directly opposite positions.

Firstly, this is the doctrine of Prof. R. Precht (Precht 2019). It lies in the fact that school material is not used by people in practice; further in their lives, most of it is forgotten. In this regard, why master this material, which is not required anywhere. Therefore, you need to train the competencies that are in demand at the present time. Such a position would not be so insidious if it were not for the further recommendations arising from it and related to minimizing the teacher's participation in training with a sharp expansion of computer education. We note right away that this approach has many negative aspects, namely how to determine the knowledge that will not be needed in the future, as well as how to establish the competencies that are needed in the present and whether they will be needed in the future. By the way, this can create additional costs that are errors in determining the need for present and future competencies. If education is completely subordinate to computer programs, then the nuances of knowledge that can only be transmitted by a person with experience will disappear from development, which makes education unnecessarily formal with the mass of restrictions that the computer itself reproduces.

Secondly, this is the position of Prof. K. Liessmann (Liessmann 2006, 2017). According to this position, the indicated transition to the formation of certain competencies with the general computerization of education is able to increase not just costs and reduce the contribution of knowledge to the growth rate but significantly reduce the quality of education with unclear but negative consequences for its development, and even to the degradation of education. This will affect Germany's leadership in high-tech manufacturing in Europe. Copying such German experience to other countries can lead them to the same result.

Quite justifiable arguments are given about the indefinite nature of competencies and the weaknesses of computer testing. Consequently, the proposed institutional reforms, supposedly for business purposes, are associated with a weakening position in the field of education of the population, with a clear intention to reduce staff with higher education, which cannot be considered as a fact that clearly contradicts the "knowledge economy".

A competency-based approach to education does not remove the main problem of education is what to teach. If it is argued that one should teach what is useful in the future, then this is a sidetrack, since people cannot know what will happen in the future, what knowledge will be needed. However, Prof. K. Liessmann rightly, in my opinion, notes that one can teach only what is known, but not unknown future knowledge. The arguments presented here constitute a significant limitation for the implementation of institutional reforms of education as the main element of the "knowledge economy" in the direction of competency training. It is necessary to take into account the costs of the rule change itself, as well as the costs of adaptation, and then the losses from inefficiencies inherent in the competency-based approach.

Since knowledge is uncertain, as is its value, its contribution to the dynamics of development will change over a long period of time, as this value changes.

However, the computerization of education may be accompanied by a decrease in the mental abilities of students, which is already noted in a number of studies (Teuchert-Noodt 2019). Therefore, two areas of institutional reform of education—electronicization and adjustment to the current needs of the business—mean introducing into the system errors and limitations of computer training, as well as erroneous preferences of the employer, determined by the current dynamics of the labor market. However, both areas of reform do not imply increased responsibility of the owner of the production for training in the workplace. These actions can lead to higher costs and lower opportunities for acquiring and disseminating knowledge, which over time, when such an education expands, lowers its quality and the contribution of knowledge to the overall dynamics of the economy. The likely loss or decrease in the potential of basic knowledge in the course of institutional transformation will reduce the overall level in solving complex intellectual problems, turning employees into a labor resource that works with data using computers. These processes are already visible in various countries.

New rules for the functioning of education can be costly. On the one hand, this increases the cost, creating a feeling of expansion of knowledge, but on the other hand, if these costs are not related to the knowledge itself, but are provoked by the rules governing their acquisition, that is, they do not emphasize the essence of knowledge, then their distorted value is formed. A significant share of these costs is not the production of knowledge, but rather the arrangement of this process. The growth of such costs is able to slow down the production of knowledge, as well as complicate their impact on economic growth. It changes the incentives to engage in scientific and educational activities.

Of great importance in the dissemination of knowledge and training is the time or speed of obtaining knowledge. Those who quickly gained knowledge and mastered and applied it will receive a greater dividend than those who hesitated in this area. Therefore, along with the direct costs of obtaining knowledge and its dissemination, it is required to take into account the time of development and use of knowledge, the speed of its acquisition. Institutional educational reforms affect this particular parameter and can change the time spent. Usually, this drawback is not taken into account in many researches, but it can be very important.

Education affects the training of personnel, the emergence of innovators, and the transformation of conservatives into innovators, as was shown above. These processes affect the dynamics of the economy, because they set the mode of innovative development.

Based on the foregoing, the assessment of the "knowledge economy" as a sector can be expanded due to the indicated circumstances arising from the complexity of the object of study—knowledge, and the new economy associated with its production. Institutional reforms require substantiation of their need, including the possibility of influencing the dynamism of economic development. Of course, the implementation of such reforms is clothed in certain justifying forms, which, given the deep consideration of all the possible consequences and negative arguments, are not such. The prospects for the influence of education and science on economic dynamics, as shown above, are determined by the magnitude of the scale of these areas of activity, their qualitative

characteristics that determine the mechanisms of the emergence of innovators, and current dynamics.

Conclusion

The development of a "knowledge economy" cannot occur without problems, as it depends on the initial level of well-being of countries, as well as the potential concentrated in activities such as education and science.

The following most significant findings were obtained during the research.

Firstly, the assessment of the "knowledge economy" by type of activity, including a certain number of diploma-educated specialists, is overstated, not to mention the fact that it does not take into account the quality of these specialists and types of activity. The author's proposed methodology provides a more rigorous assessment of both the aggregated knowledge sector itself and its contribution to the growth rate, but it is also not without limitations related to the need to take into account qualitative characteristics. However, the author's development differs from the Eurostat methodology in that it provides a specific assessment of the knowledge economy, including the contribution of this sector to economic dynamics. In those countries where the share of the "knowledge economy" is smaller, and the contribution to the growth rate is comparable to those where the share is higher, there is a higher dynamism in the development of the "knowledge economy". Where the share is comparable, and the contribution to the growth rate is less, it indicates that the "knowledge economy" rate is lower (according to the given structural formula for assessing the contribution to the growth rate).

Secondly, the qualitative state of education strongly affects the "knowledge economy," since education is an important activity in this sector. Having considered the options for institutional reforms of education discussed in Europe, we conclude that a complete rejection of basic education in favor of a transition to the development of narrow competencies will significantly limit the impact of education on the formation of a "knowledge economy," as it will reduce the yield of qualified specialists, narrowing the possibilities for their application and labor market flexibility. The competency approach can only be complementary to basic education, and institutional reforms do not lead to formalization of knowledge transfer and development. If institutional reforms provoke costs in education, they can add some dynamism to the industry, which will even support a contribution to the overall growth rate, but over time, the reduced quality of specialist output will affect the rate of economic growth.

This study focused on the measuring component, assessing the contribution of the "knowledge economy" to the pace of development, and considering strategic options for institutional reforms. The prospect of further research is the task of finding factors that accelerate the dynamics of the "knowledge economy" and its impact on economic growth, as well as identifying economic policy instruments to which the types of activities that are responsible for the emergence and use of new knowledge are most sensitive. A valuable direction will be the study of the labor structure that affects economic growth, especially taking into account the quality of training of specialists is knowledge holders, which [quality] depends on the rules of organizing the education and science system in the country.

Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

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