Formation of the knowledge economy in Russia's regions

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Abstract. The knowledge economy serves nowadays as a locomotive for the global economy and a large number of scientific studies are dedicated to inter-country comparisons and the drawing up of rankings based on the knowledge economy index. At the same time, less attention has been given to the identification of interregional differences within this sphere at the level of specific economies. In this article, the author proposes a methodology for assessing the country's regions in terms of the degree to which their economies match the knowledge economy criteria. Based on data from Russia's Federal State Statistics Service and using the Statistica 10 software package, the author distributes Russia's regions into clusters, determines the strengths and weaknesses of each of the aggregated groups of the Federation's constituents, and formulates recommendations on doing away with the "bottlenecks" impeding the formation of the knowledge economy.

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Introduction

In the 20th century, the global economy, and along with it social life, underwent changes so drastic that today's production forces in developed countries have virtually nothing in common with the means of production and the quality of workforce in the late 19th century. It is a fait accompli that over the century the leading countries shifted from the agrarian economy to the service economy, while some developing countries accomplished this leap in just a half-century's time.

The trends observed proved a consequence of long-term economic growth, a defining factor in which, according to neoclassic models, was scientific-technical progress. In essence, neoclassic models for economic growth only substantiated the long-standing hypothesis on economic growth factors, and the significance of scientific-technical progress has been understood today by not only economists but the entire society.

Unfortunately, it is really not enough to just identify the reasons behind long-term economic growth to be able to ensure it. Until this day, issues related to the mechanism for activating scientific-technical progress and the search for the "magic pill" helping accomplish a technological breakthrough have remained a matter of discussion.

The search continues, and one of the topical strands of research in this area is the "knowledge economy", the making and development whereof has been recognized as one of the top priorities for not only developed but developing countries. However, priorities voiced by many countries are about perceiving the knowledge economy as a univocally defined political goal, an imperative that does not require discussing, whereas there is also another context to construing this category – the scientific one, which presupposes perceiving the "knowledge economy" through the prism of social development, the hypothesis, which has not been proved yet, on the nature of the trajectory of society's evolution.

The first studies into the knowledge economy were undertaken in the early 1960s and involved the analysis of new sectors of the economy, which were the result of scientific progress, and their role in social and economic changes. A number of researchers [1, 2] additionally included in analysis professional services and sectors which had a high concentration of information (e.g., publishing activity), noting a high pace of growth in the employment rate in these spheres of the economy over several previous decades. The very term "knowledge economy" was put into scientific circulation by Austrian-American scholar Fritz Machlup [3] in application to one of the economy's sectors.

Among the seminal works which became the basis for the theoretical substantiation of the new role of education and knowledge in the economy's growth are the works of P. Romer [4, 5]. Romer proposed an economic growth theory that demonstrated the great significance of knowledge and innovation to economic development.

Measuring knowledge is methodologically a very subtle thing, since knowledge is a product which, on the one hand, is private and can be made one's property, while, on the other, it is public and belongs to everyone. Therefore, there formed two approaches towards measuring knowledge: one based on costs related to producing it and one based on the market value of sold knowledge. Those costs include expenditure on research and development, higher learning, and software.

The World Bank computes the Knowledge Economy Index (KEI) and the Knowledge Index (KI). The first index incorporates the Economic and Institution Regime Index, the Education Index, the Innovation Index, and the Information and Communication Technology Index. The Knowledge Index differs from the Knowledge Economy Index in the absence of the Economic and Institution Index in its composition [6].

The Networked Readiness Index (NRI) is compiled as part of a partnership between the World Economic Forum and the INSEAD business school and is also used in the analysis of the development level of the knowledge economy in inter-country comparisons. This index includes three components: the development level of the environment for information communication technology (ICT), the degree of readiness of public groups (citizens, business, authorities) for using ICT, and the level of use of communication means by these groups [7].

Among knowledge used most commonly for the inter-country comparison of knowledge economy levels is also the ICT Development Index (IDI), which has been developed by the International Telecommunication Union. The authors consider as the major objectives in computing it conducting the comparative analysis of the level and dynamics of the development of the information-communication sphere and improving the level of the use of ICT with a view to boosting the pace of economic growth and ensuring economic development [8].

Materials and methods

The author's methodology for monitoring the innovation system is oriented not towards inter-country comparisons but the search for interregional differences within the national economy. This methodology is predicated on the use of criteria that directly or indirectly characterize the state of the innovation system and presupposes generalizing indicators within the frame of four functional blocks: financial-economic, scientific-innovation, educational, and information-communication [9].

With a view to ensuring the possibility of conducting an expeditious integrated analysis of the state and dynamics of the development of the innovation system and the functional blocks that make it up, indicators with different dimensions were brought to non-dimensional form: the author determined the values of indicators of the macroeconomic model for the innovation system for the country's regions; the author found the minimal $x_{min,i}$ and maximal $x_{max,i}$ values of each indicator among regions under study; then, the dimensionless i^{th} indicator was computed using the linear scaling formula:

$$x_i = \frac{x_i - x_{min,i}}{x_{max,i} - x_{min,i}} \qquad (1)$$

Since this method is of a comparative nature, it is convenient to use it to determine not only the dynamics of innovation processes but disproportions in the innovation development of territorial formations (regions, federal okrugs, municipal okrugs, etc.) through comparing in them the intensity and scale of innovation processes, which we have taken advantage of in this study.

To minimize result distortion, we logarithmized a number of values – more specifically, GRP per capita, labor productivity, and other indicators that are not described by a linear dependency. Logarithmization helped make the nature of the dependency linear through the exclusion of accumulated growth and reflect interregional differences to a greater extent. The negative values of profit margin indicators were set to zero, since otherwise negative (but not minimal) profit margin values would be increasing the value of the integral index for the region – however, we believe that a negative profit margin at the level of a region should not facilitate this increase.

In the course of the study, based on indicators provided in Table 1 and using the STATISTICA 10 software package, we conducted their classification using the cluster analysis method. All the data is from *Regions of Russia. Social-economic indicators* (2013) and includes 2011-2012 [10].

Results

Since the biggest trouble in using cluster analysis is the determination of the number of clusters, initially we employed the visual analysis of the plot of linkage distance across steps (Figure 1; using the complete-linkage clustering method). Its results speak in favor of that regions can be broken into 4 clusters.

The construction of a dendrogram demonstrated that in dividing the regions into 4 clusters one of them would include over 80% of regions, while another cluster just 2 regions which are much different from the rest of the territories within the Federation's constituent (Moscow, Saint Petersburg).

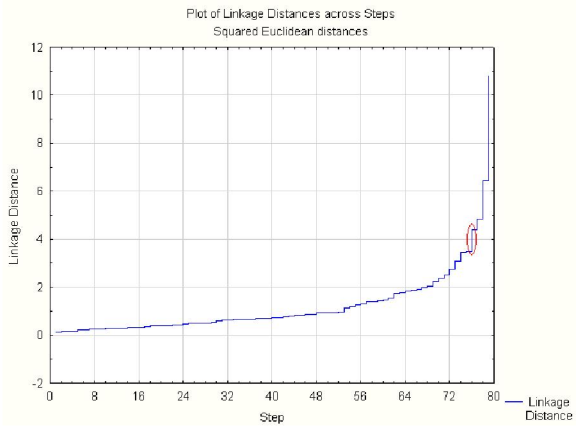

Figure 1. A plot of linkage distance across steps: squared Euclidean distances

In this regard, we decided to divide them not into 4 but 5 clusters (Complete Linkage, Squared Euclidean distances (non-standardized)) (Figure 2).

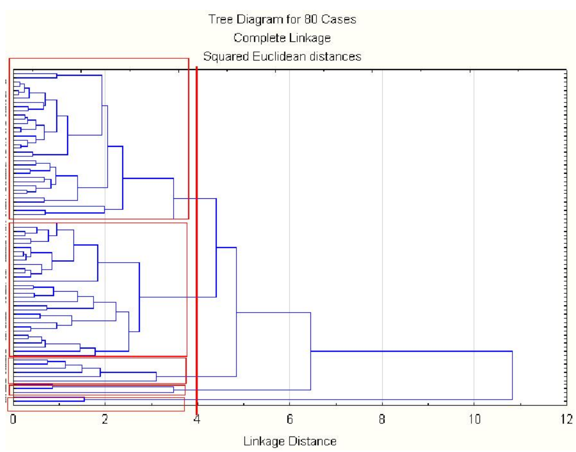

Figure 2. Marking out 5 clusters using the dendrogram construction method

The use of a more precise instrument for clusterization – the k-means clustering method – in classifying Russia's regions in terms of formation of an innovation system that meets the requirements of the innovation approach towards regional development produced a somewhat different picture. In marking out 5 groups, the largest Russian cities were not marked out into a separate cluster but were included in a group of 6 regions (Table 2), i.e. along with Moscow and Saint Petersburg it came to include Irkutsk Oblast, Tomsk Oblast, Khabarovsk Krai, and Magadan Oblast.

As part of the study, we performed a sorting of the clusters based on characteristics revealed in the course of the analysis (Figure 3).

Table 2. The groups' composition based on the k-means clustering method

Cluster A (# 2)	Cluster B (# 4)	Cluster C (# 1)	Cluster D (# 3)	Cluster E (# 5)
Moscow	Moscow Oblast	Belgorod Oblast	Tambov Oblast	Republic of Ingushetia
St. Petersburg	Republic of Karelia	Bryansk Oblast	Republic of Adygea	Chechen Republic
Irkutsk Oblast	Komi Republic	Vladimir Oblast	Republic of Kalmykia	Zabaykalsky Krai
Tomsk Oblast	Arkhangelsk Oblast	Voronezh Oblast	Astrakhan Oblast	
Khabarovsk Krai	Leningrad Oblast	Ivanovo Oblast	Volgograd Oblast	
Magadan Oblast	Murmansk Oblast	Kaluga Oblast	Karachay-Cherkess Republic	
	Krasnodar Krai	Kostroma Oblast	Republic of North Ossetia-Alania	
	Republic of Tatarstan	Kursk Oblast	Republic of Buryatia	
	Perm Krai	Lipetsk Oblast	Tuva Republic	
	Orenburg Oblast	Oryol Oblast	Altai Oblast	
	Sverdlovsk Oblast	Ryazan Oblast	Novosibirsk Oblast	
	Tyumen Oblast	Smolensk Oblast	Primorsky Krai	
	Altai Republic	Tver Oblast	Amur Oblast	
	Republic of Khakassia	Tula Oblast	Jewish Autonomous Oblast	
	Krasnoyarsk Krai	Yaroslavl Oblast		
	Kemerovo Oblast	Vologda Oblast		
	Sakha (Yakutia) Republic	Kaliningrad Oblast		
	Kamchatka Krai	Novgorod Oblast		
	Sakhalin Oblast	Pskov Oblast		
	Chukotka Autonomous Okrug	Rostov Oblast		
		Republic of Dagestan		
		Kabardino-Balkar Republic		
		Stavropol Oblast		
		Republic of Bashkortostan		
		Mari El Republic		
		Republic of Mordovia		
		Udmurt Republic		
		Chuvash Republic		
		Kirov Oblast		
		Nizhny Novgorod Oblast		
		Penza Oblast		
		Samara Oblast		
		Saratov Oblast		
		Ulyanovsk Oblast		
		Kurgan Oblast		
		Chelyabinsk Oblast		

Cluster A includes regions which based on the innovativeness criteria are the most favorable, while Cluster E, on the contrary, includes regions in which mean values across the cluster do not reach the mean value across the rest of the clusters. Clusters B, C, and D are situated between A and E, with the number of issues not resolved as of the year-end 2012 is increasing in moving from Cluster A to Cluster E.

All in all, 5 states were marked out: very high, high, medium, low, and very low.

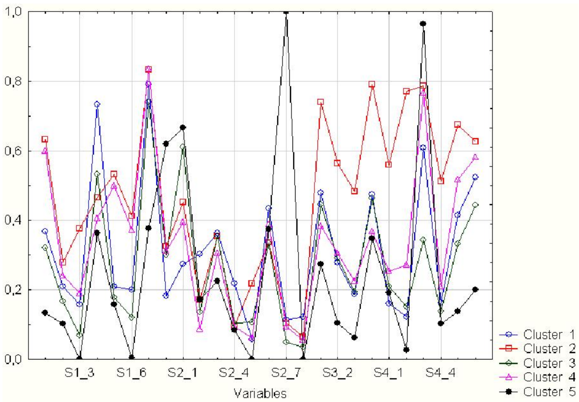

Figure 3. A plot of means for each cluster

In the course of clusterization based on the k-means method, we determined the following characteristics of the clusters. The regions within Cluster A are not losing out in terms of the mean values across the clusters and in 15 out of 16 indicators are surpassing the mean level. Against the backdrop of the overall favorable picture, what especially stands out are the values of indicators within the educational block, which are substantially above the mean level, which, really, is no wonder given the inclusion of Moscow, Saint Petersburg, and Tomsk Oblast in this group. Besides, these regions quite tangibly contrast with other Russian territories on such indicators within the information-communication block as "The number of computers per 100 employees", "Expenditure on information-communication technology per capita", and "The per-unit share of organizations that have used special programming tools for scientific research".

The obtained results of the monitoring of the innovation sphere speak in favor of the need for activating efforts aimed at boosting the profit margin of sold goods of the processing industry, the level of the scientific qualification of researchers, the per-unit share of internal current expenditures on equipment, and the quality of the inventive activity and efficiency of the inventive activity of researchers. The values of these indicators are at the medium level for the clusters marked out, which is considered a drawback for the cluster in question.

Cluster B is composed of 20 Russian regions which, on the whole, are characterized by higher values in terms of the development of the knowledge economy than across all the clusters on average, although the overall positive picture is not as exclusively positive as with the 6 leader regions. On 4 criteria ("GRP per capita", "Labor productivity", "The solvency of juridical persons", and "The efficacy of the use of labor resources"), the Federation's constituents included in this block are surpassing the national Russian level, while on one of the criteria they are losing out in terms of average Russian values – the number of students at institutions of higher learning per 10 000 citizens. We believe that the recommendation part for these regions will not be much different from Cluster A – just like in the first case, here we need one to ensure an increase, compared with the medium level, in the values of indicators which remain at the medium level. However, compared with the first cluster, Cluster B has over 20 such indicators. There is no doubt that ensuring an increase within the cluster's regions in such indicators as "The number of students at institutions of higher learning per 10 000 citizens" is an overriding objective in terms of the analysis of results, since we are observing a low value only on this indicator. However, the limited capabilities of the regional authorities in this sphere tell on such characteristics of investment in human capital as especially long pay-off times – therefore, one should not count on substantial changes on this indicator.

Cluster C is the biggest by composition. It includes 37 regions characterized by a relatively high level of the indicators "The ratio between shipped products from processing and extracting industries", "The efficacy of the use of labor resources", and "The efficiency of the inventive activity of researchers" against the backdrop of low labor productivity, poor consumer prosperity, and a relatively low scientific qualification level of researchers. Recommendations for these regions can be concentrated within the plane of remediating these three primary issues.

Cluster D includes 14 regions characterized by an extremely low share of organizations that have used personal computers as well as low labor productivity against the backdrop of quite a high degree of efficacy of the use of labor resources and a high level of researchers' scientific qualification. The combination of low labor productivity and a high degree of efficacy of the use of labor resources is by itself quite interesting, since, at first glance, the first rules out the second. This "paradox" can be explained in the following way: the efficacy of the use of labor resources characterizes the region's existing employment level (the indicator itself is computed as a ratio between the number of those employed in the economy and the size of the economically active population), and, as we know, an increase in the employment rate is accompanied, under other equal conditions, by a decrease in stimuli to labor, since when the employment rate is low employers are forced to hire the unemployed who are among the frictional and structural unemployed, i.e. engage in the production process human resources which would not be engaged before due to their not meeting relevant requirements.

Cluster E contains just 3 regions for which 12 out of 26 indicators were below the medium level. An interesting characteristic of this small group is that on such indicators as "The per-unit share of organizations that have used personal computers", "Return on new technology", and "The level of consumer prosperity" these regions are demonstrating not just high but very high values, compared with the rest of the clusters. It is not inconceivable that the high level of return on new technology can be a consequence of the low level of expenditure on research and development thanks to a relatively large groundwork laid down in the regions over the previous years – however, we shall be able to take a more in-depth look into the details of the matter only as part of additional studies.

Conclusion

In this article, the author has conducted a survey of studies into the area of the knowledge economy, its key definitions, and the more common methodologies for measuring the knowledge economy – namely, the methodology by the World Bank, the World Economic Forum, and the International Telecommunication Union.

The methodology for monitoring the innovation system presented in this article, which meets the requirements of the innovation approach towards regional development, makes it possible to conduct a comparative assessment of regions in terms of the degree to which their economies match the knowledge economy criteria, as well as determine the focus areas of regional policy in the sphere. As a result of the study, we have determined the existence of 5 clusters and determined the characteristics of each of them and the dimensions of possible enhancement for participants in the corresponding group of regions.

This study's major development focus areas are the use of indicator weights in performing the monitoring of the innovation system; deepening the detailing of results and the analysis of subgroups within clusters marked out; clusterization based on mean values across the functional groups of indicators; verification of the hypothesis on the possibility of reformatting the functional blocks based on the results of cluster analysis in using the indicators themselves as a clusterization criterion.

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