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Research of the efficiency of the use of innovative resources organizations in Belarus

Introduction

The innovative way of development requires that industrial activity be activated at the level of organizations in the form of the creation of scientific and technical developments and the introduction of investments.

The object of the research is to develop a system of indicators of the efficiency of the use of innovative resources; it can be the basis for decision-making. These indicators are designed to identify the ability of organizations to innovate, the quality of its implementation and the competitiveness of units.

The developed system of efficiency indicators do not only show how intensively science is developing in the country, but also what place it occupies in the economy.

Indicators of the effectiveness of the use of innovative resources

One of the ways to increase the efficiency of industrial enterprises and to strengthen their competitiveness is to ensure innovative filling of production. To implement the innovation strategy, the task is to improve methodological approaches to the organization of innovation activities at the enterprise. This takes into account the state of the external and internal environment, the current situation and the tasks of strategic development of the economy on the market.

In addition, in order to create an effective model for introducing innovations in a production organization, it is necessary to evaluate a number of indicators characterizing performance, sources of financing, the degree of risk, and the effectiveness of the costs incurred.

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The system of indicators of innovation activity helps the enterprise to analyze its ability to innovate, the quality of its implementation, the innovative activity of the enterprise and its competitiveness. The indicators express the strategic goals of the enterprise and motivate the staff to take initiative work.

For the analysis of the innovation process, it seems expedient to calculate a number of particular indicators of the effectiveness of the use of innovative resources of organizations.

1. Profit from the performance of scientific and technical works ($P_{R\&D}$) – the main absolute financial result of the organization. It is calculated as the difference between the cost of scientific and technical work performed and the internal costs of scientific research and development (R&D).
2. Financial efficiency or profitability of scientific and technical works reflects the effectiveness of R&D. It is the ratio of profits from the implementation of scientific and technical work to the internal costs of R&D.
3. The profitability of scientific costs (*Rc*) reflects the efficiency of the costs incurred for research and development. It is the ratio of profits of R&D to the internal costs of R&D.
4. Science intensity of GDP (SI_{GDP}), which is calculated as the ratio of the cost of domestic expenditure on research and development to the value of GDP.
5. Technological intensity (capacity) of innovative products (TI) – one of the indicators of science intensity, which is calculated as the ratio of costs for technological innovation to the cost of shipped innovative products.
6. Pay-capacity of R&D ($PC_{R\&D}$) characterizes the share of labor costs in the cost of the scientific and technical work performed.
7. Capital-labor ratio (CL) characterizes the availability of workers (T) with fixed assets (FA).
8. Working efficiency (W) characterizes the efficiency of labor costs.

The calculation of the efficiency indicators for the use of innovative resources of organizations in the Republic of Belarus is presented in Table 1.

Table 1. Indicators of the effectiveness of the use of innovative resources of Belarusian industrial organizations in 2011–2016

Indicators	Years			
	2011	2013	2015	2016
1	*2*	*3*	*4*	*5*
Internal costs of R & D ($C_{R\&D}$), thousand rubles *	208 188	437 231	449 543	475 344
including: – amount of labor pay (L), thousand rubles *	88 989	211 853	238 953	262 909
Cost volume of scientific and technical works performed (Q), thousand rubles *	222 562	565 127	544 324	596 634
Shipped innovative products (*SIP*), thousand rubles *	3 672 338	8 290 373	7 564 532	104 60 102

1	*2*	*3*	*4*	*5*
Specific weight of shipped innovative products in the volume shipped products of industrial organizations, %	14.4	17.8	13.1	16.3
Costs for technological innovation organizations, thousand rubles * (CTI) *	876 370	998 621	1 061 667	774 612
Profit from the performance of scientific and technical works, thousand rubles ($P_{R\&D}$) *	14 373	127 896	94 780	121 290
Profitability of scientific costs (*Rc*), %	6.90	29.25	21.08	25.52
Profitability of scientific and technical works ($R_{R\&D}$), %	6.46	22.63	17.41	20.33
Profitability of sales of industrial products,%	12.7	7.4	8.7	8.2
Science intensity of GDP (SI_{GDP}),%	0.68	0.65	0.50	0.50
The technological intensity (capacity) of innovative products (*TI*), %	23	12	14	7
The pay-capacity of R&D ($PC_{R\&D}$), %	0.400	0.375	0.439	0.441
Internal costs of research and development, per worker in research and development, thousand rubles *	6.7	15.1	17.2	18.0
The internal costs of research and development, per one organization that performs research and development, thousand rubles *	415.5	907.1	1024.0	1103

* Absolute figures for 2011-2015 are converted to denominated prices in 2016.

Source: Own work based on data (Science and Innovation..., 2017).

According to the table, the financial efficiency (or level of profitability) of scientific and technical works ($R_{R\&D}$) among the industry organizations of the Republic of Belarus for the period 2011–2016 increased from 6.46% to 20.33%. This significantly exceeds the gradually declining (from 12.7% to 8.2%) level of profitability of sales in general for all manufactured products of the industry. This trend characterizes the higher financial performance of research and development in comparison with the efficiency of sales of industrial organizations.

The data of the table show that after some decrease noted in 2014–2015, in 2016 there is an increase in the profitability of scientific costs (R3) to 25.52%, with a corresponding increase in the level of domestic expenditure on research and development per one organization (from 415.5 to 1103 thousand rubles in 2011–2016). Thus, the level of profitability of scientific expenditures exceeds more than 3 times the level of 2011 (6.9%). A certain conclusion may be here drawn about increasing the rationality of using funds aimed at research and development.

When researching the technological intensity (capacity) of innovative products (TI), a decrease in its level was revealed (from 23% to 7%). This indicates a faster growth in the volume of shipped innovation products (284%) compared to

a decrease in the level of costs of organizations for technological innovation (88% as compared to 2011). This characterizes the decrease in the intensity of costs for technological innovation.

As a positive indicator of innovation activity, we can note an increase in the share of shipped innovation products (works, services) in the total volume of shipped products (works, services) of industrial organizations from 14.4% to 16.3%, despite some decline observed in the years 2014–2015.

Next, we note the dynamics of the pay-capacity of R&D ($PC_{R\&D}$). Here, there is a gradual increase in the indicator (from 0.4% to 0.441%), which is consistent with an increase in the share of labor costs in the internal costs of research and development from 42.7% to 55.3%. This fact points to an increase in the level of the country's scientific potential.

RESEARCH OF THE SCIENTIFIC POTENTIAL OF ORGANIZATIONS

Many factors characterize the level of scientific potential of the country's organizations in 2011–2016. Here there are characteristics of both positive and negative dynamics.

The number of personnel engaged in research and development, from 66.5 to 58.9 people per 10,000 employed in the economy is declining in the country. Let's compare this indicator for the countries of the world (Science and Innovation..., 2017; Statistics of Science and Education, 2017; Kuznetsov, 2017). The highest level in 2015 was registered in a number of economically developed countries: Denmark (210), Finland (202), Sweden (171), Belgium (169), Switzerland (164), Austria (162), France (156), Norway (154), Germany (149), the Netherlands (146), Great Britain (133), Japan (132), Russia (115). The level of this indicator in Poland is low – 68 people per 10,000 employees.

At the same time, the structure of personnel engaged in research and development is improving: the proportion of researchers is increasing from 63% to 65.1% and the share of support personnel is falling from 29.8% to 28.7%.

The structure of the staff is improving in terms of the level of education: the proportion of employees having higher education increased from 72.7% in 2005 to 80.1% in 2016.

A study was conducted of the distribution of the personnel of Belarus engaged in research and development by sector of activity (Table 2). It shows that the largest part of scientific researchers work in the business sector, but for the period from 2011 to 2016 their share fell from 64.1% to 62.9%. The share of researchers working in the government (public) sector remained virtually unchanged. And the share of researchers in higher education increased from 9.8% to 10.9%.

Table 2. Distribution of personnel engaged in research and development in Belarus and OECD countries by sector of activity, 2015 *

Country	Government (public) sector	Entrepreneurial sector (commercial organizations sector)	Higher education sector
Belarus	**26.2**	**62.9**	**10.9**
Austria	3.9	63.7	31.8
United Kingdom	2.6	38.2	58.3
Germany	13.9	59.5	26.6
Denmark	3.4	58.0	38.2
Israel	0.8	83.7	14.9
Spain	16.3	36.9	46.6
Italy	17.6	38.6	40.0
Canada	5.7	56.0	37.9
Latvia	19.1	16.7	64.2
Norway	15.5	48.7	35.8
Poland	16.5	34.8	48.6
Russia	32.7	46.4	20.6
Slovakia	21.4	19.4	59.1
USA	…	71.1	…
Finland	9.5	56.8	32.6
France	10.2	59.7	28.7
Czech Republic	19.4	50.3	29.8
Sweden	5.1	69.0	25.7
Estonia	12.3	27.5	58.1
Japan	4.6	73.4	20.7

* Data for the Republic of Belarus are given for 2016

Source: own work based on data (Science and Innovation..., 2017; Statistics of Science and Education, 2017).

The structure of employment of scientific researchers in OECD countries is here considered. It is revealed that Belarus and Russia have the highest share of employment of scientific researchers in the government sector: 26.2% and 32.7%, respectively. This sector has a rather high share in a number of post-Soviet states: Slovakia, Latvia, the Czech Republic and Poland (Table 2).

Countries are divided into two large groups in the distribution of those employed in the economy in the business sector and the higher education sector:

- in the first group the majority of scientific researchers are concentrated in the business sector: Israel, Japan, the USA, Sweden, Austria, France, Germany, Denmark, Finland, Canada etc.;
- in the second group, the largest share is occupied by researchers from the higher education sector: Great Britain, Latvia, Slovakia, Estonia, Poland etc.

The Republic of Belarus in the structure of employment tends toward the first group.

The share of the higher education sector in the internal costs of research and development in Belarus remains at 9.6%, and the highest level was registered in 2014 at 11.4%.

The share of expenditures on education in the total amount of expenditures of the consolidated budget is reduced from 18.1% to 17.2%.

The ratio of the nominal gross average wage in education and nominal gross average wage in economy is reduced from 78.7% to 71.3%. The lowest level of this indicator was registered in 2013 (68.7%). Thus, it is necessary to create material incentives for attracting and securing workers in the sphere of education.

FINANCING INNOVATION

At present, there have been significant changes in the sources of funding for innovation. The structure of the main sources of financing innovative activity in the country as a whole among industrial enterprises in 2010 and 2016 is shown in Figure 1.

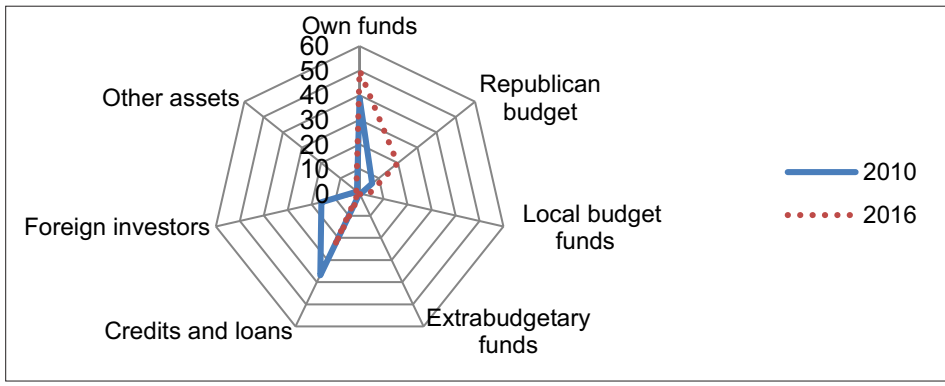

Figure 1. Composition and structure of costs for technological innovation among industrial enterprises of the Republic of Belarus by sources of financing in 2010 and 2016 [%]

Source: own work based on data (Science and Innovation..., 2017, p. 67).

Own funds are the main source of financing for innovations: in 2010 – 38.9% and 50.2% in 2016. Loans and borrowings take the second place after own funds among the main sources of innovative financing. The share of loans and borrowings in the total structure decreased from 36.9% in 2010 to 23.7% in 2016. The funds of foreign investors in 2016 significantly decreased and occupy 0.8% compared to 2010, where they accounted for 16.0%, while the republican budget grew 3 times from 6.5% in 2010 to 19.7% in 2016 year.

The processing industry received the largest share of financing from budgetary funds, with 79.5% of them directed to printing and replicating of recorded media, no more than 5% sent to other types of activity of the volume of budget financing.

The cost structure for technological innovations in industry organizations has been analyzed: the share of training and staff training costs, the acquisition of computer programs and databases, the acquisition of new and high technologies. Marketing research did not exceed 1% in 2016. An analysis of the cost structure shows that 60% of the costs were spent on the purchase of machinery and equipment.

Among the organizations of Belarus that carried out technological innovations, a large share is occupied by the manufacturing industry (about 97–98%), the largest share in its sub-sectors is occupied by the production of textiles, clothing, leather goods and fur (12% in 2010 and 16% in 2016, i.e. an increase of 4 pp); production of computer, electronic and optical equipment, production of electrical equipment (18.2% in 2010 and 16.6% in 2016, i.e. a decrease of 8.8% in 2016 compared to 2010); production of machinery and equipment not included in other groupings (23% and 18.6% in 2010 and 2016 respectively, a decrease of 19.1%).

According to statistical data on countries of the world (Indicators of Innovation, 2018; Kuznetsov, 2017), the largest proportion of organizations that received funding from the budget, in the total number of organizations that carried out technological innovation in 2015, was in Canada (70.8% of organizations) and South Korea (62, 7%). Lower rates are observed in countries such as Hungary (43.4%), the Netherlands (42.9%), Norway (38.3%), Finland (34.6%), Czech Republic (33.6%), and Belgium 32.8%). Russia, along with other post-Soviet states, has a level of this indicator reaching up to 30%. In this group there are: Russia (23.5%), Bulgaria (30%), Latvia (28.6%), Slovenia (28.2%), Portugal (26.9%), Iceland (26.8%), Poland (26.5%), Estonia (24.1%), Croatia (23.1%), Romania (20.8%), Lithuania (19.4%), and Slovakia (13.4%).

An international comparison of the share of public expenditure on R&D in GDP by countries of the world has been conducted. The level of this indicator in Belarus was quite low at 0.17%. The highest level was registered in a number of developed countries: Denmark (1.08%), Sweden (1.04%), Finland (1.0%), Germany (0.91%), Netherlands and the Czech Republic (0.87%), Austria and Switzerland (0.86%), Norway (0.79%), Iceland (0.78%) etc. The level of the indicator in Poland is at an average level of 0.5%. A fairly high level of the share of public spending was recorded in a number of post-Soviet republics: Estonia (0.8%), Lithuania (0.72%), Latvia (0.45%) (Science and Innovation, 2017, p. 133–134).

In 2016, the internal costs of research and development in Belarus amounted to 475.3 million denominated rubles. The size of the science intensity of GDP in the analyzed period continues to decrease from 0.68% to 0.50%. The country ranks third among the CIS countries in terms of the level, following Russia (1.13%) and Ukraine (0.62%). In Poland, the level of the indicator gradually increases and has reached 1%.

Thus, Belarus lags behind the leading countries of the world in terms of the share of expenditures on science in GDP. Among the world leaders there are: the Republic of Korea (4.29%), Israel (4.27%), Japan (3.28%), Sweden (3.26%), Austria (3.07), Denmark (3.01), Finland (2.9%) and Germany (2.88%), The SFS (2.79%) (Science and Innovation..., 2017, p. 129–130).

The indicator of science intensity compares the amount of expenditure on science with the level of GDP. The indicator makes it possible to understand the size of the research and development sector in the national economy.

Table 3. Distribution of internal costs for scientific research and development by sector of activity, 2016

Country	Government (public) sector	Entrepreneurial sector (commercial organizations sector)	Higher education sector
CIS countries			
1	*2*	*3*	*4*
Azerbaijan	72,4	17,8	9,8
Armenia	89.1	–	10.9
Belarus	**23.5**	**66.8**	**9.6**
Kazakhstan	25.0	51.6	16.4
Kyrgyzstan	62.1	23.3	14.6
Moldova	70.0	19.0	11.0
Russia	32.2	58.3	9.3
Tajikistan	67.0	–	33.0
Countries outside the CIS			
Austria	4.5	70.8	24.3
United Kingdom	6.8	65.7	25.6
Germany	14.9	67.7	17.4
Denmark	2.3	64.0	33.4
Israel	1.7	85.4	11.7
Spain	19.1	52.6	28.1
Italy	13.2	55.3	28.6
Canada	9.2	49.9	40.4
Latvia	25.6	24.8	49.6
Lithuania	17.2	26.9	55.9
Norway	15.1	54.2	30.7
Poland	24.4	46.6	28.9
Slovakia	27.9	27.9	43.8
USA	11.2	71.5	13.2
Finland	8.2	66.6	24.4

1	*2*	*3*	*4*
France	13.1	65.1	20.3
Czech Republic	20.4	54.3	24.9
Sweden	3.4	69.5	26.9
Estonia	10.8	46.0	41.4
Japan	7.9	78.5	12.3

Source: (Science and Innovation..., 2017, p. 131–132).

An international comparison is made of the structure of the distribution of internal costs for research and development by sector of activity. It was found out (Table 3) that this structure is consistent with the structure of the distribution of personnel engaged in research and development by sector of activity.

The study of the distribution of domestic costs for CIS countries showed that the share of government (public) sector expenditures among this group of countries is much higher than in the developed countries of the world. Moreover, the level of the government sector in Belarus was the smallest among the CIS countries (23.5%), being slightly higher in Kazakhstan (25%), Russia (32.2%) and Ukraine (37.9%).

For comparison, we will cite the share of the public sector in a number of CIS countries: Armenia (89.1%), Azerbaijan (72.4%), Moldova (70%), Tajikistan (67%), Kyrgyzstan (62.1%). This suggests that in this group of countries, scientific research is possible with substantial state support.

The study of the structure of domestic costs for countries outside the CIS (Table 3) showed that in the economically developed countries the largest share in the cost structure is occupied by the business sector, while the share of the public sector is not large. In a number of countries, the share of expenditures in the higher education sector is also quite high, e.g in Canada, Lithuania, Latvia, Slovakia, and Estonia.

These indicators characterize:

- how fast science is developing in the country;
- what place science occupies in the economy.

Analysis of the impact of investment on the level of innovation

An absolute majority of Belarusian enterprises indicate a lack of own funds and a high cost of innovations as the main or decisive factors hampering innovation (Science and Innovation..., 2017).

As a result of the conducted research it is established that innovation activity in industry, namely the amount of costs for technological innovations, is affected by the change in the level of investment in fixed assets.

The constructed linear regression model in which the dependent variable (Y) – is the cost of technological innovation, and the independent (X) – investment in fixed assets has the following form:

$$Y=25899,40+0,35\cdot X$$

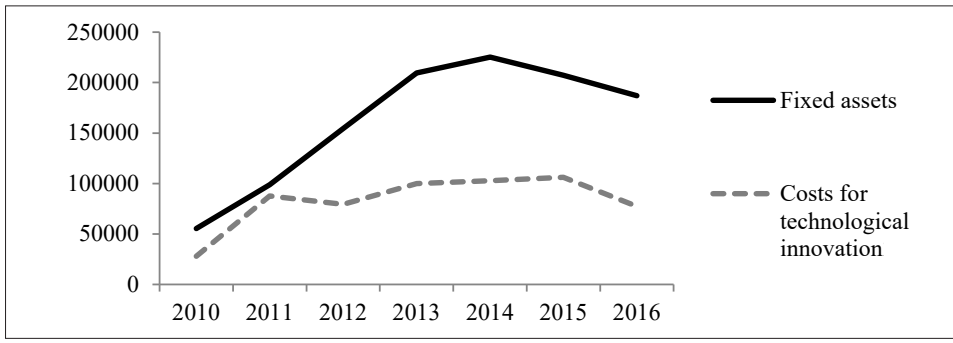

Figure 2. Dynamics of investments in fixed assets and costs for technological innovation of the Republic of Belarus in 2010-2016, mlrd. rub.*

* No denomination

Source: own work based on data (Science and Innovation..., 2017, p. 80).

The equation allows to illustrate the dependence of the level of innovation on the amount of investment in the fixed capital of the Republic of Belarus for the period from 2010 to 2016. It can be seen from the equation that with an increase in investments in fixed assets by 1 point, the cost of technological innovation increased in the Republic of Belarus by an average of 0.35 per millet points for 2010–2016.

The coefficient of determination is equal to 0.699, that is, the variation in the costs of technological innovation (result indicator) by 69.9% is explained by the variation in investments in fixed assets and by 30.1% – by the variation of all unaccounted factors.

The coefficient of regression was 0.836, that is, the relationship between the indicators is direct and strong. This shows that investments in fixed assets have a significant impact on the level of costs for technological innovation.

Using the Fisher's F-criterion (Ftable (1, 5) = 6.61, Frac = 11.594, Frac ≥ Ftable), it was determined that the model of the dependence of the costs of technological innovation on investment in fixed assets is statistically significant.

CONCLUSIONS

The most perfect system of indicators can be vulnerable to the influence of internal factors of staff's susceptibility to innovation.

The resulting system of indicators of efficiency of innovative resources use characterizes productivity of activity of the organizations from the different parties. At the same time, the indicators characterize:

- financial results of organizations,
- the effectiveness of scientific research and development (R&D),
- the efficiency of the costs incurred for research and development (R&D),
- provision of workers with fixed assets,
- the efficiency of labor costs.

Using the indicator of science intensity and its derivatives, it is possible to understand what the size of the research and development sector is within the national economy. The system of performance indicators characterizes, first, how intensively the country develops the scientific sector; second, what place science occupies in the economy.

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Summary

The ultimate goal of the study is to analyze the performance indicators of innovative resources of industrial organizations using economic and statistical methods.

The proposed system of innovation resource performance indicators characterizes the performance of organizations from the standpoint of different input vectors: the indicators express the financial performance of organizations, the effectiveness of research and development, the cost effectiveness, the provision of fixed assets to workers, and the efficiency of labor input. As a result of the analysis, the growth of financial profitability of scientific and technical works was revealed; it characterizes a higher financial performance of research and development in comparison with the efficiency of sales of organizations. The structure of employment of scientific researchers in OECD countries is considered. As the share of expenditures on education in the total amount of expenditures of the consolidated budget decreases, it is necessary to create material incentives for attracting employees and securing the existing employment in the sphere of education. An international comparison of the share of government R&D expenditures in GDP by countries of the world was carried out, and countries with high and low levels of knowledge intensity were identified. It

has been revealed that investments in fixed assets have a significant impact on the level of costs for technological innovations.

Thus, the system of indicators allows us to understand the size of the research and development sector in the scale of the country's economy.

Keywords: innovative resources, financial efficiency, research intensity, funding for research and development.

Badanie efektywności wykorzystania innowacyjnych zasobów białoruskich organizacji

Streszczenie

Celem opracowania jest ocena wydajności innowacyjnych zasobów organizacji przemysłowych przy użyciu metod ekonomicznych i statystycznych.

Analizowany system wskaźników efektywności wykorzystania zasobów innowacyjnych charakteryzuje wydajność organizacji z punktu widzenia różnych wektorów wejściowych: wskaźniki wyrażają wyniki finansowe organizacji, skuteczność prac badawczo-rozwojowych, efektywność kosztową, wyposażenie w środki trwałe (techniczne uzbrojenie pracy) oraz wydajność pracy. Wyniki analizy wskazują na wzrost rentowności finansowej prac naukowo-technicznych – badania i rozwój cechują się wyższymi wynikami finansowymi w porównaniu z efektywnością sprzedaży organizacji.

W opracowaniu analizie została poddana ponadto struktura zatrudnienia naukowców w krajach OECD. Ustalono, że zmniejsza się udział wydatków na edukację w łącznej kwocie wydatków skonsolidowanego budżetu. Wskazano, że konieczne jest zapewnienie bodźców materialnych przyciągających wykwalifikowany personel do sektora edukacyjnego. Przeprowadzono także międzynarodowe porównanie udziału wydatków rządowych na badania i rozwój w PKB według krajów oraz zidentyfikowano kraje o wysokim i niskim poziomie intensywności wiedzy. Wykazano, że inwestycje w środki trwałe mają znaczący wpływ na poziom kosztów innowacji technologicznych.

Rezultaty analiz są podstawą do wnioskowania, że rozważany system wskaźników pozwala ocenić kondycję sektora badawczo-rozwojowego w skali całej gospodarki narodowej

Słowa kluczowe: zasoby innowacyjne, efektywność finansowa, intensywność nauki, finansowanie badań i rozwoju.

JEL: O11, O15, O32.