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Transformation of Industries in the Conditions of New Technological Challenges

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Abstract: The paper substantiates the significance of the problem of developing new branches of regional specialization. The mechanisms of transformation of regional specializations are investigated. The productive role of the concept of "smart specialization" for socio-economic and industrial development is noted. The empirical base of the study was Russia's statistics for 2010-2018. The method of correlation and regression analysis identifies the influence of the way of using digital technologies on the development of traditional industries. The factors affecting the functioning of the industrial sector of Russia were identified. The current requirements and approaches to identifying the priorities of specialization of a region are given. As a result of the study, it was concluded that in order to transform traditional specialization industries and increase their competitiveness in modern conditions, their active interaction (integration and associated participation in production chains) with high-tech fast-growing industries is paramount. As expected, the introduction of new digital technologies will contribute to the growth of traditional industries, which will lead to an increase in their economic sustainability.

Keywords: industrial sector, industry 4.0, economic sustainability, digitalization, industries of regional specialization

1. INTRODUCTION

At the present stage of the development of the world economy, the role of the regional component is significantly increasing. OECD documents [27] and publications of leading scholars [7,10,32,36,37] emphasize that the global competitiveness of countries is currently largely ensured by the concentration in some territories of high-tech companies, research centers, modern production and innovation infrastructure. The most important issue in achieving sustainability is the difficulty of cooperative optimization of goals. The most important problem in achieving a stable level of economic sustainability of the industrial sector in the context of dynamic transformations is the inability to foresee, develop and implement an industrial policy that ensures joint optimization or mutual reinforcement of social goals (economic well-being, environmental quality and increasing production volumes) [22].

Conceptual provisions regarding the role of regional economies are generally summarized by Karpenko *et al*. [15]: "in the context of global integration and the transition to a 'new economy', the effective and sustainable development of the country's general mega-system can be ensured only on the basis of the competitiveness of its internal regional economic systems". The term "competitiveness" in relation to individual countries and regions began to be widely used in economic science at the end of the 20th century. Michael Porter [30] proposed the concept of a country's competitiveness, and subsequently, individual elements of the concept are reflected in the calculation of the corresponding competitiveness index proposed by Robert Huggins Associates consulting group [11]. The

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ideas of Porter contributed to the development of theoretical and methodological foundations of regional competitiveness: the theory of industrial areas of Marshall; the Italian theory of industrial districts; the Swiss theory of territorial production systems; the American clusters theory by Porter and Enright; the French academic doctrine – the theory of "poles of competitiveness" and a number of other scientific doctrines and directions.

The competitiveness of the economy, in accordance with the provisions of modern economic theory, is determined by the advantages in the development of a particular industry or group of industries, individual economic entities or their combination [38], it can be stated that the competitiveness of a region is ensured by the effective functioning of the specialization industries.

For Russia, the problem of transforming regional specialization is extremely relevant, because the industrial sector has been a backbone industry. Currently, ¼ of Russia's GDP is created in the industry. With this in mind, it seems appropriate to study the branches of the industrial sector of Russia and assess the impact on their development of modern technological trends.

In this context, it is important to understand that new rates of economic growth are ensured to a large extent due to a significant transformation of industry specialization, since it is the industries with higher growth rates that give impetus to accelerate economic development. The stated position led the authors to the formulation of *the goal of this study*, which consists in assessing the impact of new technological trends, including digital transformation of the manufacturing industry, on changing regional specializations of sectors. To this end, a hypothesis was put forward that there is a direct relationship between the volume of production in the industry and the level of development of its IT infrastructure. That is, the created information and communication infrastructure in the industry becomes a determining factor in its transformation into the region's industry of specialization. A set of academic tasks includes conducting an econometric analysis of the impact of the way of using digital technologies on the development of traditional industries; identification of the conditions for the formation of new industries, as well as consideration of problems and prospects for their development.

2. LITERATURE REVIEW

Regional specialization has an essential theoretical basis. A fundamental contribution to the substantiation of the concept of regional specialization was made by the theory of absolute advantages of Adam Smith [34] and the theory of comparative advantages of David Ricardo [31]. Later, the idea of specialization was developed by Heckscher and Olin in relation to trade [13]. In the 1980s, issues of regional specialization and the conditions for its transformation in French scientific literature were considered from the perspective of the theory of "poles of competitiveness". Aglietta and Bouillet [1] note that the ability to aggressively transform industries depends primarily on the availability of competitive poles, their strengthening and renewal. At the present stage, issues of regional specialization are disclosed in the theory of spatial competition, new economic geography, industry markets, positioning the region in a competitive environment [15].

The ongoing global technological changes, the introduction of digital technologies have formed a request for a new model of regional development. In this model, "the ability to generate new ideas, recombine existing assets and knowledge, identify promising technological trajectories becomes the main competitive advantage" [35]. The new regional development model is based on the concept of smart specialization formulated by Foray, David and Hall. The concept of smart specialization draws on a number of previous studies [8-9]. These ideas were further developed, resulting in more than a hundred publications [7, 14,18,21,23-24] etc.

An analysis of the main provisions of the concept of smart specialization allows making the following conclusion: in a generalized form, the concept identifies the potential for internal regional growth by finding unique types of economic activity that together provide the development of the region's competitive advantages in the markets for products and advanced technologies. Thus, smart specialization contributes to the activation of long-term structural changes in the economy with the transformation of regional specializations through the formation of new sectors. At the present stage, issues of regional specialization are disclosed in the theory of spatial competition, new economic geography, industry markets, and positioning the region in a competitive environment [15]. Ultimately, based on research dated 2007-2009, Foray *et al.* [8-9] formulated the concept of "smart specialization", which consists in identifying and developing unique industries for the regional economy. Scholars propose various approaches to the definition of unique fields of specialization, one of these options – the differentiated approach – is developed by the authors [17].

The continuous updating of regional specializations based on technological innovation in the search for new competitive specialization is a global trend in the global economy [29]. In these conditions, the search for methods and mechanisms for the transformation of regional specializations and the formation of new specializations, taking into account the smart specialization opportunities, are particularly relevant. There are a significant number of convincing arguments in this favor. Under these conditions, the search for methods and mechanisms for the transformation of regional specializations and the formation of new specializations are of particular relevance. According to Pilyasov, in the classical sense, regional specialization is the competitiveness (resilience) of one industry proven at the national level or a technologically coupled combination of industries that form the economic profile of a given region. Based on current trends in the development of the world economy, Pilyasov considers it necessary to revise the traditional definition of regional specialization (and, accordingly, the methods for calculating it). First of all, this is because of accounting for the global trend – a transition from macro-specialization to specialization as a result of a decrease in spatial scale to the level of part of the region. This transition is caused by the fact that the emerging need for a higher intelligence of production is being met due to the greater localization of the desired section of the process chain. Another factor that should be taken into account is the need to assess not only national but also global competitiveness in order to identify regional specialization. Diversification of a large branch of specialization leads to an increase in the number of regional specializations, or, at a minimum, to the emergence of micro-specializations.

The Russian experience shows that the transformation of regional specializations is carried out in the course of parallel processes: the consistent diversification of existing regional branches of specialization with a change in their structure; the emergence in the regions within the framework of the existing regional specialization of new highly efficient industries not in the regional but in the territorial format (new industries in technology parks, special economic zones, clusters, etc., activities of which, under certain conditions, contribute to the formation of a new economic competitive specialization of the region) [33].

The study by Kutsenko *et al.* [19] highlights the shortcomings of the existing methodology for calculating regional specialization. This is mainly due to shortcomings in the system of state statistical reporting. The indicators used in some cases do not reflect the real situation, and, therefore, distort the picture of regional specialization. Recently, in the literature, preference has been given to indicators of revealing comparative advantages and economic complexity [12,14].

A review of studies in the field of regional specialization showed that there is a prevailing opinion about the need to revise the classical definition of regional specialization and, accordingly, adjust its calculation methods.

3. MATERIALS AND METHODS

The aim of this study is to assess the impact of new technological trends, including digitalization of the industry on the transformation of regional specializations of sectors. In identifying regional promising specializations, an approach should be taken based on accounting for the potential place of the regional industrial sector in the national market of goods and technologies, and for a number of commodities – positioning in the system of international markets. This approach is complemented by taking into account new technological trends in the sectors of current and potential regional specialization; diagnostics of promising technologies with a potential to form new sectors of economic growth; with a reference to the formation of new segments of the knowledge economy.

As part of the study, it is proposed to use a number of indicators of the economic sustainability of industrial enterprises. These indicators are analyzed in dynamics and segmented into five groups: market potential; production potential; innovation potential; financial potential; HR potential (Fig. 1). Initial data on the indicators of each segment were collected from Rosstat for the period from 2010 to 2018.

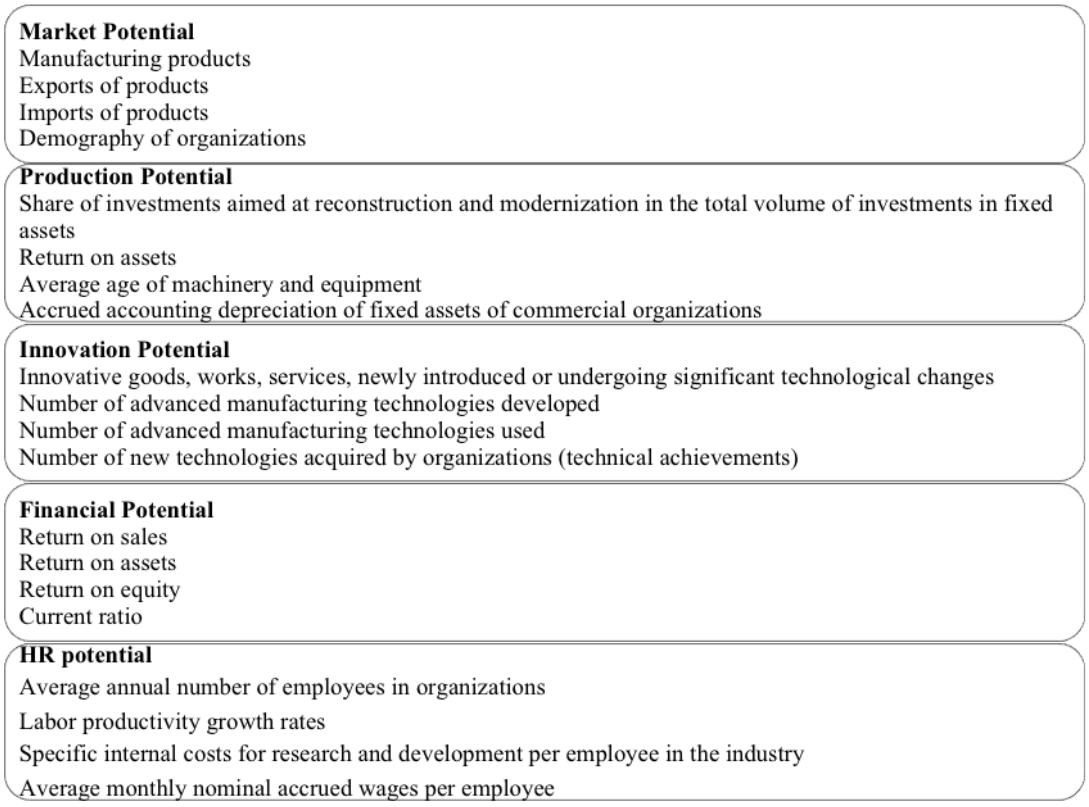

Fig. 1. Indicators for assessing the economic sustainability of the industrial sector

One of the main methods for assessing economic sustainability is the method of comparing the actual values of indicators with their threshold values. For convenience, assessing the degree of remoteness of indicators from their threshold values, indicators are reduced to a dimensionless form using normalizing methods and displayed in a single coordinate system. The choice of normalizing determines, as a rule, the dynamic range of visualization of the results [25].

Normalizing was done according to Mityakov [16]:

– for the ratio of "not less than the threshold value":

$$\bar{x} = \begin{cases} 2^{(1-a/x)/\ln(10/3)}, \text{if } x/a > 1; \\ 2^{-\log 10/3(a/x)}, \text{if } x/a \le 1. \end{cases} \quad (1)$$

– for the ratio not exceeding threshold value:

$$\bar{x} = \begin{cases} 2^{(1-a/x)/\ln(10/3)}, \text{if } x/a < 1; \\ 2^{-\log 10/3(a/x)}, \text{if } x/a \geq 1. \end{cases} \quad (2)$$

where x is the actual value of the indicator; a is its threshold value; $\bar{x}$ is normalized value.

The interpretation of the comparison of the obtained normalized estimates is as follows: $\bar{x}=1$ corresponds to the equality of the indicator and its threshold value, $\bar{x}<1$ indicates a threat to economic stability (the indicator has not reached its threshold value), $\bar{x}>1$ corresponds to the indicator reaching its threshold value, i.e. in this case, the indicator is in a stable zone.

One of the main indicators of the operational stability of the industrial sector is considered to be the market component, namely the growth of production output. To this end, a hypothesis was put forward that there is a direct relationship between the volume of production in the industry and the level of development of its IT infrastructure. That is, the created information and communication infrastructure in the industry becomes a determining factor in its transformation into the region's industry of specialization.

To test the hypothesis, the linear regression modeling method is applied, the significance of the obtained equations is established using the coefficient of determination (R^2). The equation of the linear regression has the form:

$$\bar{y} = a + bx \quad (3)$$

where y is the average value of the effective indicator; x is the influencing factor; a and b is regression coefficients.

The coefficients of the regression equation can be interpreted in this case as follows. If a> 0, then with increasing the coefficient x, fiscal security increases, and if a <0, then with increasing the coefficient x it decreases.

To check the adequacy of the equation, the coefficient of determination is calculated:

$$R^2 = 1 - \frac{\sum(y_i - a x_i - b)^2}{\sum(y_i - \bar{y})^2} \quad (4)$$

where y_i is the level of socio-economic sustainability in the i-th year; x_i is factor assessment in the i-th year; $\bar{y}$ is the average level of socio-economic sustainability over several years.

To verify the adequacy, the Fisher test was used:

$$F = \frac{R^2}{(1-R^2)}(n-2) \quad (5)$$

where R^2 is the coefficient of determination; n is the sample size.

If the value of F exceeds the critical value in absolute value, then the equation is adequate and can describe existing patterns. The obtained regression models are used to predict possible prospects for the development of the industrial sector depending on the expected values of sectoral technological development. In this forecast, the point type of the forecast was conventionally applied to visually indicate the trend of the digital transformation of industry.

4. RESULTS

As part of the study, development indicators for the industrial sector of Russia, including enterprises of processing and construction industries (Appendix A), were selected. The indicators are defined from the perspective of the industry's characteristics for five development potentials – market, production, innovation, financial, and HR.

From Appendix A, it is seen that for many indicators there is a negative trend of change. To calculate the economic sustainability of industrial enterprises, it is necessary to bring all indicators to a single normalized value. The calculations on normalizing the indicators for assessing the economic sustainability of the industrial sector make it possible to form curves

of indicators of changes in the economic stability of the industrial sector of Russia for the five considered potentials as shown in Fig. 2.

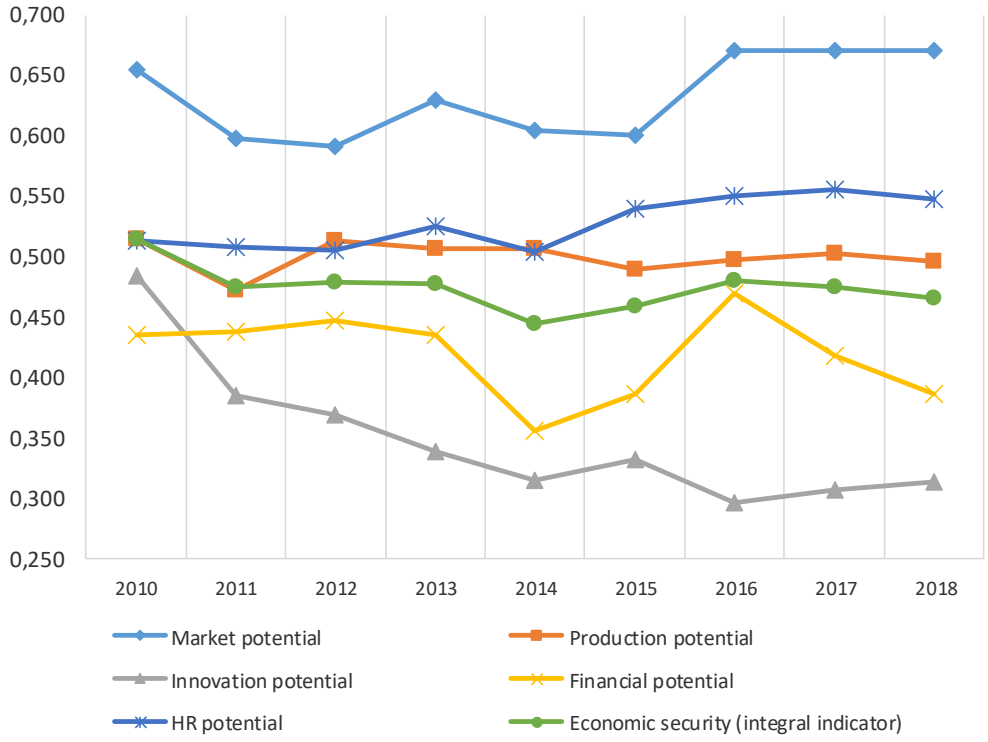

Fig. 2. The dynamics of indicators of economic sustainability of the industrial sector of Russia for 2010-2018

Fig. 2 shows that the sustainability of the industrial sector is most determined by the market potential of economic security. It is important to note that the production potential of the industry is more stable and less affected by the crisis of 2014, in contrast to indicators in the context of finance and innovation (innovation and financial potential). As is known, the introduction of innovations and modern technologies is one of the main components of economic growth [6,20,26]. One of the challenges of technological development at the moment is digitalization [2,4,5]. To assess the level of digitalization in the industrial sector, the authors consider the dynamics of a number of indicators characterizing this process. Appendix B provides information on the use of information and communication technologies. In 2017, the share of organizations using personal computers in construction is 88.9%, and in processing – 95.5%.

Currently, digitalization processes affect the mineral wealth sector of the economy to the greatest extent and the construction sector to the lowest. It is important to note that in terms of the use of personal computers, there is a negative trend in all considered sectors.

In this study, the authors will identify the trend component that describes the impact of the digitalization level of industries on the development of the industrial sector. For this purpose, paired linear regression equations are constructed that describe the time series of the main growing trend under consideration (Figs. 3-6). As this level, the authors determined the average value of the indicator “the use of information and communication technologies in organizations” as a percentage of the total number of examined organizations of the corresponding type of activity, which is an exogenous (influencing) variable. The endogenous (dependent) variable (y) is the value of the volume of own-produced shipped goods, own works and services provided.

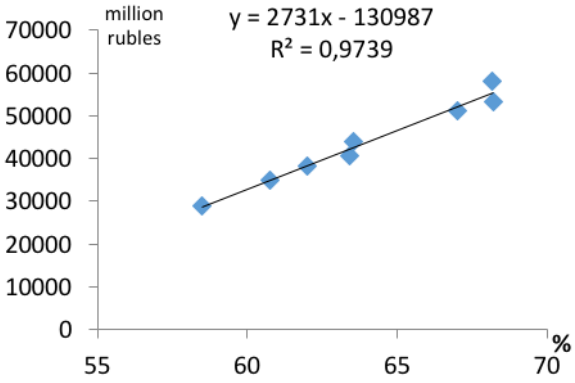

Fig. 3. The dynamics of the digitalization trend for the industrial sector as a whole, 2011-2018

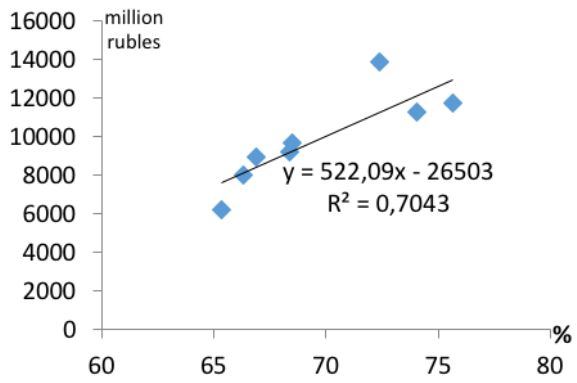

Fig. 4. The dynamics of the digitalization trend for the mineral wealth industry, 2011-2018

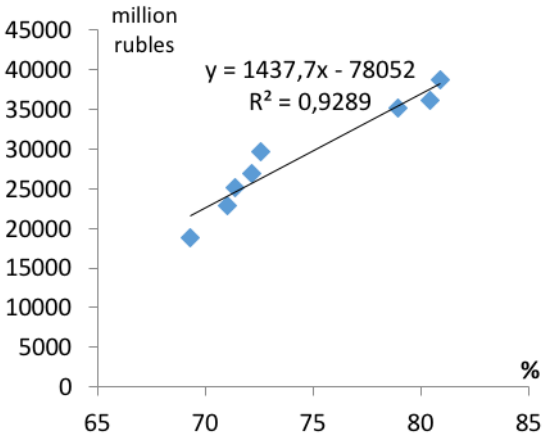

Fig. 5. The dynamics of the digitalization trend for the processing industry, 2011-2018

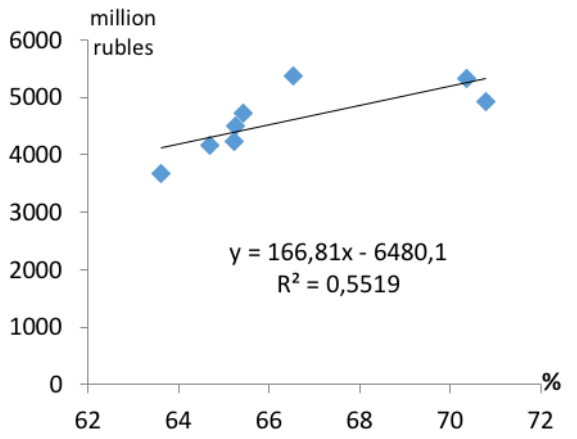

Fig. 6. The dynamics of the digitalization trend for the construction industry, 2011-2018

Analyzing the obtained equations, one can conclude that the relationship between the level of production and the level of digitalization of the industry is close. The highest value of the coefficient of determination was found in the processing industry of the economy, a weaker value is observed in the construction industry. This conclusion can also be drawn by examining the values of the coefficients of the dependent variable: β = 1,437.7 in processing, β = 522.2 in mineral wealth mining, to the lowest degree the level of digitalization affects construction (β = 166.8). The variability of the development of the industrial sector of Russia from the level of digitalization is shown in Table 1.

Table 1. Variability of the digitalization status of the industrial sector of Russia

Indicator	*Regression equation*	*Determination coefficient*	*Fisher test*	
			Predictive	*Critical*
Total	y=2,731x – 130,987	0.9739	2.1629	2.0048
Mineral wealth mining	y=522.09x – 26,503	0.7043	0.8758	2.7764
Processing	y=1,437.7x – 78,052	0.9289	1.6503	4.3026
Construction	y=166.81x – 6,480	0.5519	0.6211	3.1824

The significance of the obtained equations was checked using the Fisher test. Based on the calculated critical value of the Fisher test, the authors accept an alternative hypothesis and conclude that there are statistically significant differences in the frequency of outcome depending on the impact of the factor. According to the established pattern, there is a rather strong dependence of the volumes of own-made products on equipping the production environment of IT infrastructure.

5. DISCUSSION

The advent of new technologies leads to the modernization of existing industries and the emergence of new ones. Traditional industries of regional specialization of the industrial sector are supplemented by new ones such as ICT, industries using biotechnology, photonics, robotics, artificial intelligence, etc. The authors present the results of a rating of the costs of Russian regions for ICT. In 2013, the cost of ICT in Russia as a whole amounted to 69.5 billion rubles. By 2019, this figure increased by 2.3 times. Note that in industrialized regions the growth rate of this indicator is even higher, for example, in the Sverdlovsk Region over the same period, ICT expenses increased by 2.5 times (from 1.06 to 2.73 billion rubles); in the Chelyabinsk Region, ICT expenses increased by 4.5 times (from 0.26 to 1.14 billion rubles).

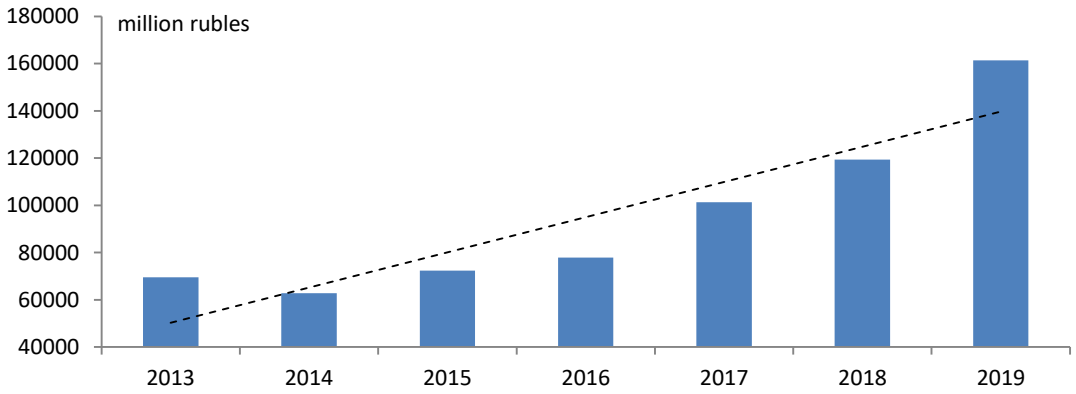

Fig. 7. Dynamics of costs for information and communication technologies in Russia

These trends suggest support for the continued use of ICT. The presence of an information barrier in the growth of companies has been repeatedly noted in studies [39]. The dependencies obtained earlier allow comparing the growth of the real sector of the economy with the growth rate of using ICT in these sectors. Here is the forecast for the development of the Russian industry as a whole, as well as in mineral wealth mining, processing and construction (Figs. 8-11). This forecast is based on the obtained relationships of the influence of the digitalization level on the development of the industrial sector. The digitalization trend, as mentioned above, in this study is described by the average of indicators such as the share of enterprises in the relevant industry using personal computers, servers, local area networks, global information networks, and the share of organizations that have a web page.

The forecast for the development of the manufacturing industry as a whole shows that, while maintaining the average growth rate of the digitalization in the industry (2.2% per year), the predicted volume of industrial goods and services by 2023 may amount to more than 76.9 billion rubles, and the average growth of this indicator will be more than 8% a year.

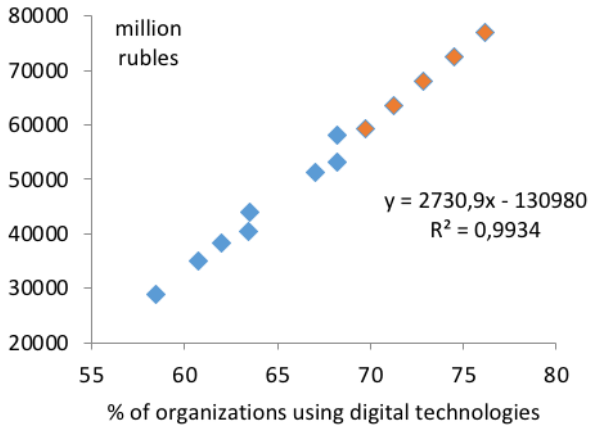

Fig. 8. Forecast of the impact of the digitalization trend on the industrial sector as a whole for the period of 2019-2023

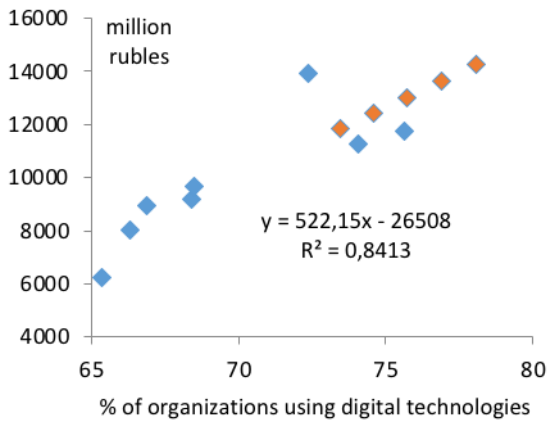

Fig. 9. Forecast of the impact of the digitalization trend for the mineral wealth industry for the period of 2019-2023

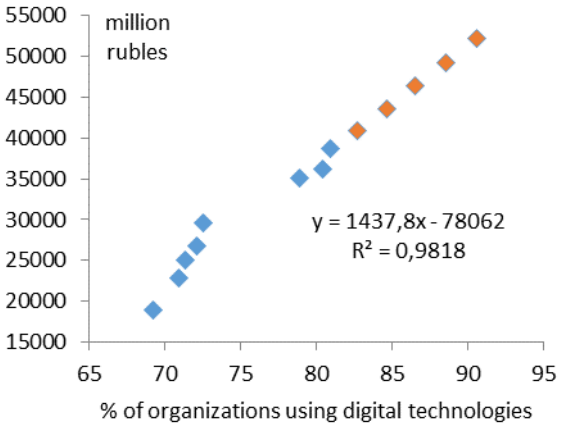

Fig. 10. Forecast of the impact of digitalization trend for the processing industry for the period of 2019-2023

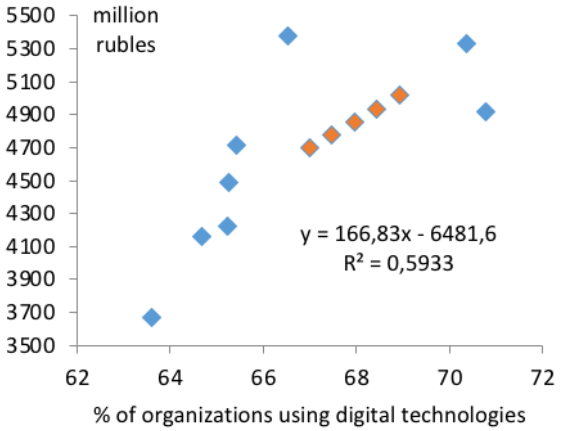

Fig. 11. Forecast of the impact of the digitalization trend for the construction industry for the period of 2019-2023

The digitalization trend of the mineral wealth industry has somewhat slower dynamics of changes and a lower connection with the resulting volume indicator. While maintaining the existing average growth rate (about 1.5% per year), by 2023 the volume of output in the mineral wealth mining industry will amount to more than 14.24 billion rubles per year, and the average growth rate in the industry is about 7% per year. The highest degree of digitalization is noted in the processing industry, and here the predicted growth values will be about 2.2% per year. This will allow the industry to reach a production level of over 52 billion rubles per year by 2023, provided that 90% of organizations in this industry will use digital technology (under this condition, the industry will show average growth rates at almost 9%).

The construction industry has shown the least degree of digitalization. The predicted share of organizations using digital technologies in the industry by 2023 will be less than 70%. The output volume will approach 5 billion rubles, and the average growth rate in the construction industry will be about 2.8% per year. The obtained data on the dynamics of industrial development make it possible to formulate a forecast for the structure of the real sector of the national economy (Fig. 12).

Fig. 12. Real and forecast structure of the real sector of the economy

Fig. 12 shows a gradual decrease in the share of the construction industry, as well as of mineral wealth mining, which is caused by lower development rates of these industries compared to the processing industry. That is, the influence of new technologies and the digital transformation of the manufacturing industry contributes to positive structural changes in the economy. An increasing degree of influence of new technologies, including ICT, will inevitably contribute to the transformation of the manufacturing industry. Industries of regional specialization will also be transformed. The study showed that existing technological trends must be taken into account, as they have a significant impact on the development of the economy.

The results of this study suggest that the feature of new industries is rapid growth, accumulation and combination of various types of resources, of great importance for their development is scientific and industrial cooperation, interregional interaction and scientific collaboration [3]. One of the popular tools for the development of new technologies is such a kind of strategic planning and management of the regional economy as smart specialization. This concept makes it possible to single out individual specialized activities that do not correspond to the profile type of the region, but represent a unique highly specialized niche in the markets of high-tech products, services and technologies, i.e. creation of effective promising regional specializations [28].

6. CONCLUSION

This paper identifies the factors that influence the transformation of regional specializations, taking into account the global challenges of technological development. The role of digitalization in increasing the competitiveness of industries with promising economic specialization of the region was identified, which is due, inter alia, to cooperative inter-industry interaction and the level of development of innovative infrastructure. The results obtained confirm the hypothesis that the created information and communication infrastructure in the industry is becoming a determining factor in its transformation into the region's industry of specialization. That is, digitalization in the aspect of regional development is a mechanism that allows certain sectors to achieve competitiveness. Therefore, there is an objective need to take into account the level of digitalization in the methods for identifying regional specialization. These methods should account for not only traditional approaches based on the inter-regional division of labor and the rational

distribution of productive forces, but also the priority of high-tech industries and their digitalization level. Thus, the modern methodological approach to identifying the specialization of the region should be guided to a greater extent by the qualitative indicators of development, their technological transformation of the economy and the current market situation.

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APPENDIX A

Table. Indicators of the potential of the industrial complex of Russia (for enterprises of processing and construction industries)

Indicator	2010	2012	2014	2016	2018
Market potential					
Dynamics of income, %	100.00	111.11	108.30	104.15	105.00
Ratio of the production index and the index of changes in numbers (in % to the previous year)	107.6	104.2	103.5	101.3	102.9
Index of changes in labor intensity and index of changes in the working time in % of the production index (in % to the previous year)	110.5	96.4	96.7	99.4	99.2
Costs of production and sale of products per 1 ruble of manufactured products, kopecks	75.3	77.2	80	80.1	80
Production potential					
Share of investments aimed at reconstruction and modernization in the total volume of investments in fixed assets	18.8	19.5	17.4	16.3	15.5
Index of physical volume of investments in fixed assets aimed at reconstruction and modernization, %	103.5	107.1	92.5	95.1	101.6
Average age of machinery and equipment available at the end of the year	11.1	11.5	11.2	11.3	12.2
Index of changes in capital productivity, %	100.9	104.2	88.7	101.2	97.0
Innovation potential					
Volume of innovative goods, works, services, billion rubles	1.244	2.873	3.580	4.364	4.516
Index of physical volume of investments in fixed assets aimed at reconstruction and modernization, %	103.5	107.1	92.5	95.1	92
Number of advanced manufacturing technologies used, units	236	350	439	548	524
Number of new technologies (technical achievements) acquired by organizations, units	119	63	28	14	48
Financial potential					
Return on sales, %	10	8.6	7.3	7.6	12.3
Return on assets %	6.7	6.1	2.5	5.9	6.4
Equity to total assets ratio	0.52	0.48	0.4	0.42	0.48
Current ratio	1.34	1.25	1.21	1.24	1.01
HR potential					
Average annual number of employees in organizations, million people	16.901	17.166	17.111	16.941	17.06
Labor productivity index	105.2	104.8	102.5	100.2	95.9
Index of changes in capital-labor ratio, %	102.2	99.3	113.5	100.9	103.00
Average monthly nominal accrued wages per employee, thousand rubles	9.078	24.512	29.511	34.592	40.722

Source: Rosstat.

APPENDIX B

Table. Digitalization indicators of the industrial sector of Russia (at the beginning of the year)

Indicator	*2012*	*2014*	*2016*	*2018*
PCs				
Total	94.1	94.0	92.3	92.1
Mineral wealth mining	94.6	95.6	93.1	90.7
Processing	97.3	97.2	97.1	95.5
Construction	96.0	94.3	92.9	88.9
Servers				
Total	19.7	19.7	47.7	50.6
Mineral wealth mining	30.0	30.4	69.9	69.1
Processing	25.9	25.2	67.4	74.5
Construction	20.7	19.4	61.2	58.0
Local area networks				
Total	71.3	73.4	63.5	61.1
Mineral wealth mining	85.1	86.3	78.3	73.3
Processing	84.2	85.2	76.6	76.2
Construction	82.7	81.6	68.3	59.9
Global information networks				
Total	85.6	88.7	89.0	89.7
Mineral wealth mining	91.8	92.9	91.8	89.0
Processing	94.3	95.2	96.0	94.5
Construction	92.5	92.3	91.4	87.1
Web pages				
Total	33.0	41.3	42.6	47.4
Mineral wealth mining	30.0	36.8	37.2	39.7
Processing	53.3	57.9	57.5	63.8
Construction	34.3	38.7	40.1	38.7

Source: Rosstat.

