Assessment of the digital transformation impact on the structural changes dynamics in the Russian economy

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Abstract: The purpose of this study is a quantitative assessment of the structural changes dynamics; the authors propose to assess these shifts based on an analysis of changes occurring within the economy sectoral structure and the gross value added in recent years. Another purpose is to identify the relations between economic development and the digital technologies use in the Russian economy in general, which allow to evaluate the effectiveness of the strategy implementation as part of the development of the Digital Economy in the country in general. The Gatev’s coefficient is the most effective tool for calculating the magnitude of structural changes, it allows to evaluate the dynamics of changes, as well as to identify structural changes based on the effectiveness. The empirical base of the study consists of statistical materials on the gross value added reflected in the industry structure, statistical publications on the use of various types of digital technologies and on digital technology expenses from 2005 to 2022. The study identified the trends of the Gatev’s structural changes coefficients dynamics and provided their quantitative assessment according to the selected indicators for Russia. An analysis of the comparability of economical structural changes both in terms of the use and the costs of digital technologies was carried out. The obtained results of the quantitative assessment served as the basis for substantiating the identified dynamics for the quantitative assessment of the structural changes taking place in the country's economy and the dynamics of the use of digital technologies.

1 Introduction

The current state of economic development is characterized by trends in both the expansion of the scope of digital technologies and the accelerated development of the digital economy itself, which is based on the use of the Internet with the focus on the consumers. This process generates new factors of economic growth and influences its dynamics. Recent studies of economic growth consider structural changes not only as a result, but also as new opportunities for sustainable development. This study proposes an approach that allows us to quantify these changes, as well as to analyze their relations with the IT sector development, to identify changes in the dynamics of the digital technologies implementation, and to assess
the impact of the information society development key factors on the structure of the national economy.

Since 2017, a beginning of a new stage in the development of the digital economy was observed in Russia, which led to the formation of a methodological base for official statistical information. The implementation of this approach is carried out in the course of monitoring the fulfillment of the tasks described in the decrees of the President of the Russian Federation, the orders of the Government of the Russian Federation, and in strategic documents [2]. In addition, monitoring also accumulates the achievement of target indicators of the national program "Digital Economy of the Russian Federation". Thanks to this, there are more opportunities to analyze the collection of statistical information, both in the development of the digital economy and the social sphere in general.

A quantitative assessment of the structural changes taking place in the regional economy was studied in the works of Sukharev [12, 13], Lyakina [9], Stroeva, Gorelova [11], Kudaev [8], Gasanov [4].

Fundamental studies of structural changes in the economy are reflected in the works of Kazinets [5, 6], Krasilnikov [7], Sukharev [12, 13]. The most commonly used in research integral coefficients are: Kazinets’ [5, 6], Gatev’ and Ryabtsev’ [10].

2 Materials and method

This study is based on official statistics which is publicly available on the Internet in the statistical digest of the Federal State Statistics Service (Rosstat) “Regions of Russia. Social and economic indicators” from 2005 to 2022 [3].

The article proposes an assessment of structural changes, the calculations are based on the Gatev’s integral coefficient:

$$K_t^G = \sqrt{\frac{\sum_{i=1}^{n}(x_i - x_{i-1})^2}{\sum_{i=1}^{n}x_i^2 + \sum_{i=1}^{n}x_{i-1}^2}}$$

where:
- $x_i$ is the $i$-th industry share in the gross indicator in period $t$,
- $x_{i-1} \geq 0$;
- $x_i \geq 0$; $n$ is the number of structure elements.

The coefficient calculation is based on a comparison of the sum of squared deviation of the shares of the corresponding economic sectors in the gross value for the indicators in the current and previous periods and the sums of the corresponding specific gravities, calculated as a standard deviation (1). The values of the obtained indexes can vary from 0 and above; the closer the value is to zero, the less changes are occurring. The structure remains unchanged if the indexes’ value is equal to 0. And vice versa, an increase in the coefficient’s value characterizes large-scale changes in the structure. This method of structural changes evaluation makes it possible to determine the presence and dynamics of structural changes, but it does not allow to assess them qualitatively. To solve this problem, this study proposes to investigate a combination of various factors when calculating structural shifts in both economics and digital technologies and compare the changes dynamics.

To assess structural changes at the initial stage of the study it is important to determine the set of indicators for the evaluation. In this paper we used the following statistical indicators that were collected from official statistics: the sectoral structure of gross value added, the usage of digital technologies, and the digital technologies expenses from 2005 to 2022.

The calculations take into account that the sectoral structure of gross value added before 2016 included 15 sectors (according to the Federal State Statistics Service). Since 2017, the
methodology for calculating this indicator by sectoral structure has been changed, 6 new sectors [3] were included, and at the moment it includes 20 components.

For the first time were included such industries as information and communication and professional, scientific and technical activities, which is of particular interest for this research. The paper proposes to assess the impact of the digital technologies implementation and its costs on the development of the economy in general by assessing structural shifts in the Russian economy.

Therefore, the calculations until 2016 were carried out according to the previous industry structure, and the calculations from 2017 were made according to the new one, which is reflected in the diagrams, where there is a break in the curve of the Gatev’ coefficient values. This affects comparability of the obtained coefficient values, however, it reflects certain changes in the structure.

3 Results

As a result of the calculations, we identified a heterogeneous dynamics of structural changes in gross value added in Russia from 2006 to 2020. The most drastic structural changes are observed during the crisis periods in the Russian economy from 2008 to 2010 and from 2017 to 2020 (see Fig. 1).

![Fig. 1. Dynamics of the Gatev’s structural changes coefficient for the gross value added sectoral composition in Russia. Source: Compiled by the authors based on [3].](image)

It can be noted, that shown in Fig. 1 curve of Gatev’s coefficient values reflects non-uniform changes in the sectoral structure of the Russian economy; there are abrupt changes in the graph. The most significant structural changes are observed in 2006, 2009, 2018 and 2019. Since the sectoral structure of the Russian economy includes 20 industries, the shown dynamic probably does not mean that in other periods (from 2010 to 2016) there were no changes, it is possible that they could cancel each other out.

The drastic drop in the Gatev’ coefficient from 0.08 to 0.02 in 2008 reflects the impact of the global financial and economic crisis on the Russian economy (Fig. 2).
On Figure 2 the dynamics of the Gross Domestic Product per capita in Russia has been added to the dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition. The combined analysis of these indicators reflects the decline in GDP per capita for the first time since 2008. This confirms the beginning of a large-scale crisis in 2019-2020, which is associated both with the start of the coronavirus pandemic and the restructuring of the economy under new circumstances as part of a general decline in economic activity.

The next stage of the analysis reflects the impact of the digital technologies usage on structural changes in the economy. In official statistics the usage of digital technologies (until 2018 it was referred by the term Information and Communication Technologies) in organizations is represented by four indicators: the use of personal computers (X_1), the use of servers (X_2), the use of local area networks (X_3), the use of cloud services (until 2013 it was referred by the term global information networks) (X_4). The integral indicator (Y) “Use of digital technologies, total” was calculated as the sum of normalized indicators X_1, X_2, X_3, X_4.

Until 2010 there was practically no connection between structural changes and the usage of digital technologies, since digital technologies were only at the initial stage of their development and could not have a significant impact on the country's economy (Fig. 3).
The next issue that is being addressed in our study is to determine which of the indicators of the usage of digital technologies ($X_1$, $X_2$, $X_3$, $X_4$) reflect the greatest changes. The results are presented in fig. 4-7, that also reflect the change correlation in the graphs of structural changes and the corresponding indicators.

**Fig. 3.** Dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition and the usage of digital technologies in Russian organizations. *Source:* Compiled by the authors based on [3].

**Fig. 4.** Dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition and the usage of personal computers in organizations in the Russian Federation. *Source:* Compiled by the authors based on [3].
Fig. 5. Dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition and the usage of servers in organizations in the Russian Federation. Source: Compiled by the authors based on [3].

Fig. 6. Dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition and the usage of local area networks in organizations in the Russian Federation. Source: Compiled by the authors based on [3].
Fig. 7. Dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition and the usage of cloud services in organizations in the Russian Federation. Source: Compiled by the authors based on [3].

The most distinct decline in 2020 is observed in the usage of local area networks and personal computers in organizations, this is primarily due to the companies’ transition to remote work during the pandemic. The negative change in the usage of servers and cloud services in organizations, this may be due to the partial production interruptions of some organizations and the incorporation of stay-at-home period during the pandemic.

Of greatest interest is the analysis of the impact of the indicator of the expenses on digital technologies on structural changes in the sectoral structure of gross value added (Fig. 8).

Fig. 8. Dynamics of the Gatev’ structural changes coefficient for the gross value added sectoral composition and the costs of implementation and usage of digital technologies in the Russian Federation. Source: Compiled by the authors based on [3].

As a result of a graphical comparison of the curves, a similar positive trend was identified, that shows the presence of a positive impact in the long-term (because the expenses don’t lead to an immediate result, and represent investments that will provide a result over a certain period of time) and are in coherence with the dynamics of structural changes. In 2011 and
2012 a significant expenses increase contributes to a significant increase in Gatev’ structural changes coefficient in 2013 and 2014. An expenses decrease in 2014 led to a decrease in structural changes in 2016. Since 2017 expenses growth has been increasing significantly every year, and corresponding changes are taking place in the structure of the Russian economy. Based on the analysis of the above graphs, we can conclude that the sharp decline in the Gatev’s value in 2020 is not caused by a decrease in investment in the digital technologies field, but by other global negative trends that led to a decline in economic development throughout the country.

The analysis is supplemented by a correlation-regression analysis of the IT industry development indicators and the gross domestic product values the per capita in the Russian Federation. In the course of the correlation analysis, we selected the most significant indicators of the IT industry, and excluded the multicollinearity of the model parameters. The result of the regression analysis is a linear multiple regression equation, the final results of which are presented in Table 1.

Table 1. Results of regression analysis.

<table>
<thead>
<tr>
<th>Equation Statistical Significance Indicators</th>
<th>R² = 0,996</th>
<th>F (3,7)=1057,3  p &lt; 0,00001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficients</td>
<td>Standard Error</td>
</tr>
<tr>
<td>Y-intercept</td>
<td>-471079</td>
<td>0,03</td>
</tr>
<tr>
<td>X17</td>
<td>9132</td>
<td>0,020028</td>
</tr>
<tr>
<td>X18</td>
<td>21741</td>
<td>0,029776</td>
</tr>
<tr>
<td>X20</td>
<td>25615</td>
<td>0,02925</td>
</tr>
</tbody>
</table>

Source: Compiled by the authors based on [3]

So we obtain the following equation:

\[ Y = -471079 + 9132X_{17} + 21741X_{18} + 25615X_{20} \]  \hspace{5cm} (2)

where:

\( Y \) — gross regional product per capita in Russian Federation

\( X_{17} \) — Share of organizations that placed orders for goods (operations, services) on the Internet, in the total number of surveyed organizations

\( X_{18} \) — Share of organizations that received orders for manufactured goods (operations, services) via the Internet, in the total number of surveyed organizations

\( X_{20} \) — Number of graduates of state higher education institutions majoring in Informatics and Computer Engineering per 10,000 population

Thus, the indicators characterizing the e-commerce development and IT-majoring education programs have the greatest positive impact on the gross regional product. Moreover, the obtained coefficients of the equation are significant, which confirms the strong influence of the information society development on the digital economy.

4 Discussion

In 2017, new large-scale economic changes were observed in Russia, in particular, Russian President Decree of May 9, 2017, No. 203, “On the Strategy for the Development of the Information Society in the Russian Federation for 2017-2030” (2017) was issued [1]; the program "Digital Economy of the Russian Federation" was developed and later approved by the Government of the Russian Federation (2017) [14]. This program emphasizes the special role of digital information, it is noted that digital data has become a key factor in production.
in all areas of socio-economic activity. At the present stage, it is digital technologies that can most effectively increase the country's competitiveness, improve the quality of life of its citizens, as well as ensure economic growth and national sovereignty. Therefore, since the beginning of this period, the implementation of the activities specified by these strategic concepts and programs leads to large-scale changes in the information technologies usage in all areas of both the economy and public administration and brings the Russian Federation to a new level of information development. This is also confirmed by a quantitative assessment, which is reflected in the values of the Gatev’s coefficient (Fig. 1). From 2017 to 2019, structural changes occur at a high rate, and in 2020 there is a sharp decline. It can be assumed that this is due to the general decline in economic activity in Russia. Since 2011 the results of the implementation of the state program "Information Society" and federal target programs are already influencing the structure of the Russian economy, which is reflected in a similar change in both indicators from 2011 to 2015 and 2017 on the graph. The decline in the digital technologies usage also corresponds to a significant negative change in the of structural changes coefficient. An analysis of the change correlation in the graphs confirms the relations between the studied processes. It is most likely that the growth in 2015-2019 is due to the transition of the Russian economy to a digital one, as it was announced in 2017 in the “Digital Economy of the Russian Federation Program”. The decline in 2020 can be explained by the beginning of the coronavirus pandemic and the decrease in economic activity in all sectors, including the changing conditions for the IT industry, as even an increase in the use of the Internet by organizations does not make it possible to compensate for the decrease in production in other sectors. In 2021, the Russian economy began to stabilize and adapt to the current circumstances, and there is an increase in the usage of digital technologies indicator, which will probably lead to an increase in the Gatev’s value.

5 Conclusion

Thus, the obtained assessment of structural changes in the gross value added sectoral structure allowed us to determine the periods of significant changes in the economic structure as well as to characterize the dynamic changes in the information technologies usage. Furthermore we identified the relations between the structural dynamics in the economy and the dynamics of expenses for the digital technologies usage, which confirms the effectiveness of the trends and processes that were implemented in the digital technologies area in this period. Since 2017, there has been significant changes both in the economy and in the digital technologies, which is due to their mutual positive influence. The first changes in the digital transformation began with the development and implementation of the State Program "Information Society" (from 2011 to 2020), which was aimed at improving the availability and quality of public services, developing digital literacy among the population, sustainable economic growth of the country with the help of modern information, telecommunications and digital technologies, as well as a new vector of development which represents the implementation of the "Digital Economy of the Russian Federation" program of 2017, defined in the Strategy for the Development of the Information Society in the Russian Federation for 2017-2030, approved by the Presidential Decree.

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