RES MILITARIS
REVUE EUROPEENNE D ETUDES EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

Production Function As A Tool For Studying The Impact of Digital Transformation on The Region's Economy

By

Marat Rashitovich Safiullin
Kazan Federal University, Center of Advanced Economic Research in the Academy of Sciences of the Republic of Tatarstan

Rafis Timerkhanovich Burganov
Kazan State University of Architecture And Civil Engineering Volga Region State University of Physical Culture, Sports and Tourism

Leonid Alekseevich Elshin
Kazan Federal University, Kazan State University of Architecture And Civil Engineeringe-mail

Abstract

The purpose of this study is the development, based on the modernized Cobb-Douglas production function, the toolkit for diagnosing the economic dynamics of regional socio-economic systems in the context of economic relations digitalization. The subject of the study is methodical approaches to a formalized assessment of the region digital transformation impact on the parameters and prospects of its economic growth (using the example of the Volga Federal District regions). Based on the results of the study, the models were built that determine the influence degree of the main production factors (labor, capital, digital transformation) on the dynamics of GRP growth in the studied groups of regions. They identified the key patterns of the regional socio-economic system digitalization influence of the Volga Federal District on the regional economic dynamics. The results obtained form the basis for the most effective and adaptive trends development to intensify economic growth in the regions in accordance with the concept of digital technologies diffusion into the economic environment.

Keywords: production functions, digital transformation, technological paradigms, digital economy, region, economic growth, sustainable development, regional competitiveness, models of economic dynamics.

Introduction

According to a number of leading Russian and foreign economists [1-7], the digitalization of the socioeconomic environment is and will be the most important factor of competitiveness at the regional and national levels. And this is not accidental, since it contributes to the most important task solution of the socio-economic growth of territories: the growth of the population life quality, social progress, the development of human capital, the optimization and improvement of business models, balanced and sustainable development, the integration of economic agents into a single communication environment within the development of digital intelligent spaces, etc. It is no coincidence that nowadays the strategic vector of the Russian economy development is focused on strengthening the potential and configuring the system of productive factors that provide stimulation of economic process digitalization.

It is important to emphasize that the level of “digital” potential, which provides the possibility of promising technological solutions creation and replication, will largely determine the region adaptation prospects to basic technological shifts and form “windows of opportunity” within the framework of emerging challenges within the global and national socio-economic systems. In this regard, the studies on the significance and extent of the of digital transformation impact on the processes of socioeconomic dynamics have acquired a high level of demand from the scientific and expert community in recent years.

Methods

A review of theoretical approaches [8, 9, 10, 11] demonstrates that the whole variety of production functions focuses, as a rule, on the inclusion of three key factors in their arguments: labor, capital, and scientific and technological progress. At the same time, a macro-parameter is most often used as scientific and technological progress that evaluates innovations. Considering that the category of "innovations" is very broad in terms of interpreting the processes and results that are formed in the framework of R&D, this study proposes to focus on one of its components - the digital transformation of the eco-environment as a new institution that regulates economic relations, and, consequently, launches the processes of innovative activity and economic dynamics intensification. Thus, the production function obtained in this way will have a more concentrated character and will help to determine the contribution of the digital factor to the development of socio-economic systems by the most direct way at both macro and meso levels.

Relying on the presented approach, the corresponding calculations and estimates are further implemented (using the example of the Volga Federal District regions). Methodically, the problem was solved within the framework of multifactorial model development based on the modeling of power and exponential production functions using econometric tools.

They used the following indicators evaluating the change of production factors:

T (labor) - the number of employees (thousand people, the indicator value for the year);

L (capital) - the availability of fixed assets at the end of the year at full book value for a full range of organizations (million rubles, the indicator value for the year);

D (digital transformation) - the values of indicators characterizing the effectiveness of regional economic system digitalization;

I – expenses of organizations for technological innovations (the indicator value for the year), million rubles.

All indicators are preliminary normalized in order to unify the measurement scale for each factor.

In a generalized form, based on the systematization and aggregation of approaches, the production function of economic growth can be represented as the following function:

$$Y = A * K^{\alpha} * L^{\beta} * D^{*\gamma} * I^{*\delta} \text{ (formula 10)}$$

where,
Y – the gross domestic product of the region, billion rubles;

T – the contribution of labor to GDP growth, billion rubles;
L - the contribution of capital to GDP growth, billion rubles;
D - the contribution of digital transformation to GDP growth, billion rubles;
I - the contribution of scientific and technological progress to the GRP growth, billion rubles.

The coefficients α, β, γ, δ are elasticity parameters showing how much GDP will grow if the corresponding factor grows by 1%.

The most important tool to solve the problem posed in this study is an integral assessment of the time series that characterizes, in an aggregated form, the level of digital transformation of the region. Methodically, this problem is solved on the basis of the proposed and successfully tested methods by Safiullin M.R., and Elshin L.A. [12]. It is based on a formalized analysis of the key areas of digitalization, enshrined in the Decree of the Russian Federation Government (July 28, 2017): standard regulation; personnel for the digital economy; development of research competencies and technological reserves; information infrastructure; information security.

Figure 1 shows the algorithm that determines the aggregate index of the region digital transformation in accordance with the outlined approach.

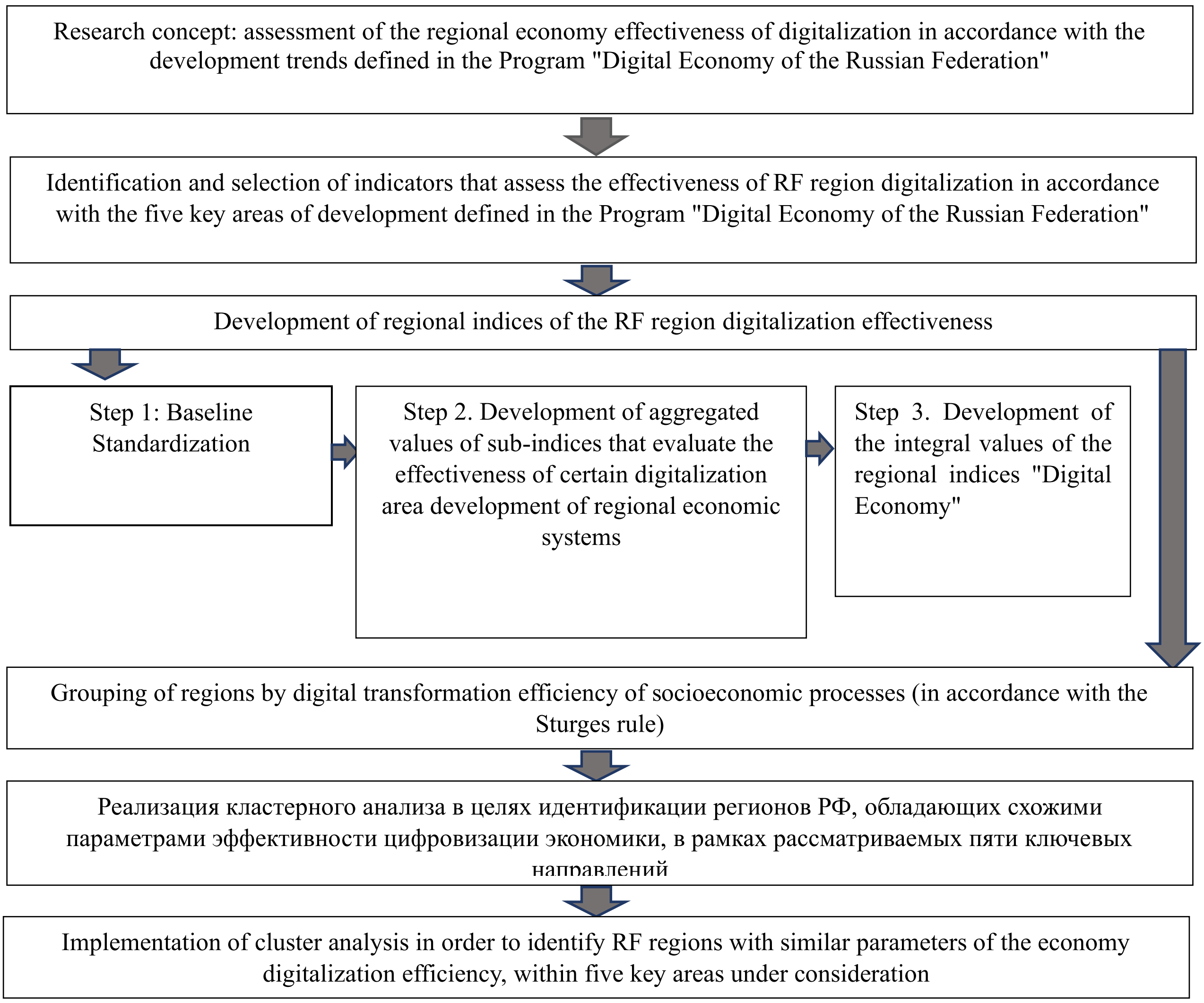

Figure 1 - Algorithm for digitalization effectiveness evaluation of regional economic systems The results of its approbation (using the example of the regions of the Volga Federal District) are presented in Table 1.

The estimates obtained, characterizing the integral value of digitalization index of the socio-economic environment, formed the necessary and sufficient conditions for production function development in relation to the studied regional group.

Results and discussion

Relying on the obtained estimates of the region digital transformation index (factor D of the production function), as well as based on the obtained normalized estimates of the factors T; L; I (according to the data of statistical monitoring bodies), an attempt was made to develop a production function. As the data, in relation to these factors, they used the statistical indicators of Rosstat. For the parameter comparability they carried out the standardization (normalization) of the initial indicators.

As the part of the first stage of production function development, the obtained standardized data were taken as logarithms in order to transfer to the linear form of the simulated function. In order to eliminate multicollinearity the factor I was excluded from the regression model. Further, using the example of the Volga Federal District regions, we will demonstrate the results of reproducible iterations.

Before proceeding to the main results of the study, it is advisable to demonstrate the sequence of calculations using the example of one of the regions. The Republic of Tatarstan was chosen as such. Table 2 presents the primary calculations within the framework of the analyzed set of factors.

Table 2 - Logarithmic values of the production function factors

№	LnY	LnT	LnL	LnI	LnD
2005	-3,65	-4,53	-2,29	-3,08	-0,23
2006	-3,37	-4,14	-2,16	-2,85	-0,22
2007	-3,08	-3,76	-2,03	-2,61	-0,21
2008	-2,79	-3,37	-1,91	-2,37	-0,20
2009	-2,50	-2,99	-1,78	-2,14	-0,19
2010	-2,66	-5,23	-1,78	-2,67	-0,20
2011	-1,77	-1,57	-1,24	-1,28	-0,15
2012	-1,45	-0,47	-1,43	-1,51	-0,16
2013	-1,21	-0,61	-1,30	-0,67	-0,15
2014	-1,00	-0,27	-1,25	-0,18	-0,14
2015	-0,68	-0,20	-1,02	-0,97	-0,14
2016	-0,45	-0,19	-0,87	-0,85	-0,13
2017	-0,28	-0,42	-0,72	-0,40	-0,09
2018	-0,10	-0,55	-0,59	-0,03	-0,11
2019	-0,05	-0,52	-0,03	0,23	-0,07
2020	0,49	-1,13	-0,03	0,47	-0,09

The results of the regression analysis are presented in the resulting equation:

$$LnY = 0{,}374+0{,}097LnT+1.008LnL+0.628LnD$$

Table 1 Values of indicators characterizing the effectiveness of regional economic system digitalization

Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Republic of Bashkortostan	0,74	0,74	0,73	0,74	0,735	0,75	0,76	0,79	0,83	0,8	0,81
Kirov region	0,61	0,63	0,66	0,62	0,65	0,62	0,59	0,65	0,63	0,64	0,67
Mari El Republic	0,6	0,62	0,67	0,58	0,65	0,61	0,55	0,63	0,6	0,67	0,76
The Republic of Mordovia	0,61	0,66	0,69	0,62	0,67	0,63	0,65	0,66	0,62	0,61	0,67
Nizhny Novgorod Region	0,79	0,84	0,9	0,85	0,8	0,86	0,91	0,9	0,92	0,94	0,93
Orenburg region	0,68	0,72	0,65	0,7	0,75	0,78	0,8	0,81	0,77	0,76	0,79
Penza region	0,5	0,56	0,5	0,47	0,53	0,44	0,45	0,46	0,51	0,56	0,97
Perm region	0,72	0,75	0,76	0,74	0,78	0,82	0,76	0,79	0,76	0,8	0,79
Samara Region	0,8	0,81	0,79	0,81	0,84	0,82	0,85	0,8	0,86	0,84	0,84
Saratov region	0,65	0,68	0,65	0,66	0,68	0,62	0,63	0,65	0,66	0,71	0,74
Republic of Tatarstan	0,86	0,9	0,85	0,86	0,87	0,87	0,88	0,91	0,9	0,93	0,91
Udmurt republic	0,65	0,66	0,64	0,66	0,69	0,66	0,71	0,67	0,71	0,69	0,67
Ulyanovsk region	0,69	0,72	0,7	0,72	0,68	0,72	0,78	0,77	0,68	0,72	0,69
Chuvash Republic	0,6	0,63	0,64	0,6	0,6	0,61	0,63	0,63	0,68	0,69	0,74

The obtained parameters of the model statistical significance allow us to conclude that it is adequate. This, in turn, allows us to conclude that it can be used in the future for analytical purposes and for prognostic estimate development.

Having transformed the resulting equation from a logarithmic form into a power function, the following equation was developed:

$$Y = 1.45*T^{0.097}*L^{1.008}*D^{0.628}$$

Similar estimates were made for other subjects of the Volga Federal District. The results are presented in the table 5.

Table 5 - The parameters of GRP elasticity in the regions of the Volga Federal District to the studied set of productive factors

№	Region	Factor T	Factor L	Factor D
1	Republic of Bashkortostan	0,292	0,875	0,411
2	Mari El Republic	0,327	0,516	-0,479
3	The Republic of Mordovia	0,217	0,742	0,403
4	Republic of Tatarstan (Tatarstan)	0,097	1,008	0,628
5	Udmurt republic	0,317	-0,054	0,319
6	Chuvash Republic - Chuvashia	0,158	0,711	0,607
7	Perm region	0,241	0,526	0,683
8	Kirov region	0,844	0,275	0,410
9	Nizhny Novgorod Region	0,199	0,942	0,614
10	Orenburg region	0,500	0,702	-0,148
11	Penza region	-0,051	0,595	0,047
12	Samara Region	0,541	0,846	0,712
13	Saratov region	0,197	0,941	-0,077
14	Ulyanovsk region	0,218	0,841	0,009

Conclusions

The estimates obtained indicate a significant level of the region GRP elasticity differentiation to the analyzed productive factors. At that, despite this largely predictable result, it is worth noting that the digital transformation factor is not equally significant for all the subjects of the Volga Federal District. For example, the value of elasticity coefficients has a negative sign with the factor D for such regions as the Republic of Mari El, the Orenburg region and the Saratov region. This means that the diffusion of digital technologies in this regional group leads to GRP level decrease. Undoubtedly, this conclusion contradicts our hypothesis. The observed fluctuation of the elasticity coefficients for these regions is acceptable within the framework of the regression analysis. However, this requires further research.

Meanwhile, the parameters of the "Digital transformation" factor significance for the studied population of the Volga Federal District subjects are still in a very wide range and are characterized mainly by a positive contribution to the GRP growth. In many ways, the revealed differentiation can be associated with the adaptation level of the regional institutional infrastructure, characterized by a different level of susceptibility to innovations, which include digitalization processes. The studies of Russian and foreign scientists echo this conclusion, which also assert the differentiated nature of regional socio-economic system susceptibility to digitalization processes [13, 14, 15, 16]. Besides, the observed differences in the processes of digital transformation may be related to the structural features and characteristics of the economy of the studied regions. However, considering the still significant level of this factor influence on economic growth, it is extremely important to overcome the barriers that limit the diffusion of digital transformation at the regional level.

Summary

Finally, it must be stated that the implemented assessments fully demonstrate not only the high level of the digital transformation factor significance for modern economic systems, but also prove empirically the need to intensify the mechanisms which stimulate the introduction of digital technologies into the system of economic relations. This, as calculations show, will contribute significantly to accelerated economic growth. Considering that the digital economy today, in the conditions of the sixth technological paradigm, which is gaining momentum, is of particular importance, from the point of view of ensuring sustainable, competitive development, the put forward postulate acquires a special level of relevance.

Acknowledgements

The work is performed according to the Kazan Federal University development program "Priority-2030".

References

Hospers G.J., Benneworth P.S. (2012) Innovation in an old industrial region: the case of Twente. International journal of learning and intellectual capital, 2012, vol. 9 (1/2), 6-21.

Brennen S. and Kreiss, D. (2014). Digitalization and digitization. Culture Digitally, 8. URL: http://culturedigitally.org/2014/09/digitalization-and-digitization/) (Reference date: 10.05.2022)

Babkin A.V., Burkaltseva D.D., Kosten D.G., Vorobyov Yu.N. Development of the digital economy in Russia: essence, features, technical normalization, development problems // Bulletin of St. Petersburg State Polytechnical University. Economic sciences. 2017. V. 10, No. pp. 9-25.

Muminov N.G., Zakhirova G.M. The role of public procurement in the economy digitalization and in the introduction of electronic commerce. Bulletin of St. Petersburg State Polytechnical University. Economic sciences. 2020. V. 13, No. 2. pp. 30–39. DOI: 10.18721/JE.13203

Internet development trends: from digital opportunities to digital reality: Analytical report / G.I. Abdrakhmanova, S.A. Vasilkovsky, K.O. Vishnevsky [and others]. - Moscow: National Research University "Higher School of Economics", 2022. - 228 p. – ISBN 978-5-7598-2602-6. –DOI 10.17323/978-5-7598-2602-6.

Digital technologies in the Russian economy: Analytical report / K.O. Vishnevsky, L.M. Gokhberg, V.V. Dementiev [and others]. - Moscow: National Research University "Higher School of Economics", 2021. - 116 p. – ISBN 978-5-7598-2199-1. – DOI 10.17323/978-5-7598-2199-1. – EDN ZJQWHB.

Breakthrough innovations: human 2.0: Report to the XXIII Yasinsky (April) international scientific conference on the problems of economic and social development, Moscow, April 4-2022 / S.A. Gavrish, L.M. Gokhberg, D.E. Gribkova [et al]. - Moscow: National Research University "Higher School of Economics", 2022. - 56 p. – ISBN 978-5-7598-2649-1. – DOI 10.17323/978-5-7598-2649-1.

Gray K. (2015) Models for digitalization. Soft & Systems Modeling, , vol. 14, issue 4, 1319-1320

Birch K., MacKinnon D. and Cumbers, A. (2010) Old Industrial Regions in Europe: A Comparative Assessment of Economic Performance. Regional Studies, vol. 44, issue 1, 35-53

Sopina N.V., Kan E.N. Dependence of Russia competitiveness level on the degree of information and communication technologies development // Economic relations. 2020. Volume 10, No. 2, pp. 395–408.

Pfohl E, Yahsi B., Kurnaz T. (2015) The impact of Industry 4.0 on the supply chain. HICLConference proceedings, 31-58.

Elshin L.A., Safiullin M.R., Abdukaeva A.A. Evaluation of the digital transformation effectiveness concerning the economy of Russian regions // Economic Bulletin of the Republic of Tatarstan. 2019. No. 3. pp. 5–12.

Yudina, T. N. Digital segment of the real economy: digital economy in the context of analog economy / T. N. Yudina // St.Petersburg State Polytechnical University Journal. Economics. – 2019. – Vol. 12. – No 2. – pp. 7-18. – DOI 10.18721/JE.12201.

Bondarenko, V. M. Digital Economy: A Vision From The Future / V. M. Bondarenko // Journal of Economic Science Research. – 2020. – Vol. 3. – No 1. – pp. 16-23. – DOI 10.30564/jesr.v3i1.1402.

Safiullin M.R. Evaluation and analysis of digital transformation of RF regional economic systems: methodological approaches and their testing / M.R. Safiullin, A.A. Abdukaeva, L.A. Elshin // Bulletin of the University. - 2019. - No. 12. - pp. 133-143. – DOI 10.26425/1816-4277-2019-12-133-143. – EDN GTLVPL.

Safiullin M.R. Influence of shock "impulses" on the development of the regional economy industrial sector (using the example of the Republic of Tatarstan) / M. R. Safiullin, L.A. Elshin, M.I. Prygunova // Economic Bulletin of the Republic of Tatarstan. - 2014. - No. 4. - pp. 5-11. – EDN TBZVWV.