On the Possibility of Econometric Modeling of Estimates of Economic Complexity

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Abstract: One of the modern ways to reflect diversification is the concept of economic complexity. A relatively recent approach has been developed to measure economic complexity using data on the structure of exports by country. In a number of studies, the authors of this publication have obtained estimates of the economic complexity of regions based on tax revenue data reflecting the production volumes of 82 sectors. The following describes the possibility of obtaining estimates of the complexity of regional economies based on data on production volumes for 24 types of economic activity. Estimates of economic complexity remain highly stable during the transition from data on sectors to data on types of economic activity (TEA). The procedure for preparing initial information for calculating estimates of economic complexity by type of economic activity is simpler than by sector. Estimates of the regression of the index of economic complexity of regions by sectors into three explanatory variables are presented: the index of economic complexity of regions by types of economic activity, the first and second main components of the structure of the economy by types of economic activity. The results obtained confirm the possibility of econometric modeling of estimates of economic complexity by sectors using estimates of complexity and the main components of the structure of production volumes by type of economic activity. Estimates of economic complexity can be used to determine the priority directions of economic development of regions and the country as a whole.

1 INTRODUCTION

One of the modern ways to reflect diversification is the concept of economic complexity. Relatively recently, works (Hausmann, Rodrik 2003; Hausmann, Hwang, Rodrik, 2006; Hidalgo, Hausmann, 2009; Hartmann, 2017) have developed an approach for measuring economic complexity using data on the structure of exports by country. In the work (Lyubimov et al., 2017), this concept was applied to data on the structure of exports by regions of Russia. The authors of the work (Afanasiev, Kudrov, 2021) obtained estimates of the economic complexity of Russian regions based on tax revenue data reflecting the production volumes of the sectors.

The increase in the economic complexity of regional economies is associated with solving the problems of ensuring economic security. The topic of economic security is sufficiently fully reflected in the works (Voloshenko, 2018; Voloshenko, 2021), where it is noted that the economic security of the region should not be considered in isolation from economic complexity. When choosing the direction of development of the region, it is necessary to take into account its capabilities, potential and risks.

Regions with high economic complexity and, consequently, with a large amount of accumulated knowledge are usually more resistant to economic shocks and more competitive at the international level. Understanding economic complexity can help in planning and implementing socio-economic development strategies, ensuring more efficient allocation of resources and improving the quality of life. Modern research proves the positive impact of the growing complexity of the territory's economy on its socio-economic development (Kravchenko, 2017; Reynolds, 2018; Roos, 2018), labor productivity, employment and job retention (Ruus et al., 2020; Antonis, 2019; Roos, 2017), reduction of income

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inequality (Bandeira, 2021), export diversification opportunities (Kadochnikov, Fedyunina, 2013; Kotsofana, Stazhkova, 2011; Farra, 2013), diffusion of innovations (Hartmann, 2019; Hidalgo, 2018). Estimates of economic complexity can be used to determine priority areas for the development of the economy of regions and the country as a whole (Polovyan, 2020; Karaev, 2022).

The paper (Afanasiev, Ilyin, 2022) suggests an approach to assessing priority areas of diversification based on recommendations for the development of sectors. At the same time, the diversification of the region's economy is associated with the emergence of a new strong sector. The approach is focused on increasing the economic complexity of the regional economy. The methodology used makes it possible to take into account and display in real time in the initial information considered by any region the decisions already taken by other regions, which is an urgent task for the system of situational centers. A significant statistical dependence of the index of economic complexity with indicators of socio-economic development characterizing the quality of life has been established: average per capita income, unemployment rate, natural population growth rate, GRP per capita, agricultural products per capita and morbidity from neoplasms (Afanasiev, 2022; Afanasiev, Gusev, 2023). Thus, the orientation of the region to increase economic complexity can contribute to an increase in the quality of life of the population.

2 RESEARCH METHODOLOGY

The description of the initial data and the approach to calculating estimates of economic complexity (EEC) of the subjects of the Russian Federation by economic sectors are presented in the work (Afanasiev, Gusev, 2022). To describe the structure of the regional economy, data on the volume of shipped products by types of economic activity (TEA) can be used. First, we will determine the indicator of the RCA_{kj}revealed comparative advantages (Balassa, 1965):

$$RCA_{kj} = (y_{kj} / \sum_j y_{kj}) \,/\, (\sum_k y_{kj} / \sum_{kj} y_{kj}), \qquad (1)$$

where y_{kj}– the volume of production by TEAj of the region k; RCA_{kj}— the ratio of the share of production by TEA $j$in the total volume of production by all TEA of the region $k$to the share of production by TEA $j$of all regions in the volume of production by all TEA of all regions. To identify comparative advantages in regional economies in accordance with the work (Hausmann, Klinger, 2006), we will use an indicator $RCA_{kj}$for which a condition of the type of restriction from below is checked. Namely, if the value RCA_{kj}exceeds one, then it is considered that the economy of the region $k$has identified comparative advantages in the output by TEA j; if the value RCA_{kj} is less than one, then there are no identified comparative advantages:

$$a_{kj} = \begin{cases} 1, & \text{если } RCA_{kj} \geq 1; \\ 0, & \text{если } RCA_{kj} < 1. \end{cases}$$

The matrix $A = (a_{kj})$with elements 0-1 contains data on TEA, which in different regions are developed at the level of the identified comparative advantages. The rows of this matrix correspond to regions, the columns correspond to TEA. The vector $(a_{kj_1}, \cdots, a_{kj_m})$will be called the structure of strong TEA of the economy of the region k.

According to the standard approach (Hausmann, Hwang, Rodrik, 2006; Hidalgo, Hausmann, 2009: Hartmann, 2017; Afanasiev, Kudrov, 2021), the concept of "***economic complexity of a region***" is considered as a characteristic reflecting the level of its technological development, which is determined by strong TEA in the structure of its economy. Accordingly, the economic complexity of TEA depends on the level of technological development of those regions in the structure of which this TEA is developed to the level of a strong one. The economic complexity of the region is proportional to the average level of economic complexity of strong TEA in the structure of its economy:

$$ECI_k = a_1 \sum_j r_{kj} ECI_j,$$
$$r_{kj} = a_{kj}/q_{k0}, \;\; q_{k0} = \sum_j a_{kj} \qquad (2)$$

Here q_{k0}– the number of strong TEA in the economy of the region; r_{kj}– the weighting factor; a_1— a positive constant.

The economic complexity of TEA is proportional to the average level of economic complexity of the regions in the structure of the economies of which this TEA is strong:

$$ECI_j = a_2 \sum_k r^*_{jk} ECI_k,$$
$$r^*_{jk} = a_{kj}/q_{j0}, \, q_{j0} = \sum_k a_{kj} \qquad (3)$$

Here $q_{j0}$is the number of regions in which TEA is strong; r^*_{jk}– the weighting factor; a_2— a positive constant.

Let $\boldsymbol{c} = \left(ECI_{k_1}, ECI_{k_2}, \cdots\right)^T$ — vector-column of EEC values for regions; $\boldsymbol{p} = \left(ECI_j, ECI_{j_2}, \cdots\right)^T$ — vector-column of EEC values of complexity for TEA; $\boldsymbol{R}_1 = \left(r_{kj}\right)$, $\boldsymbol{R}_2 = \left(r_{jk}^*\right)$— weight matrices. From the relations (2) and (3) it follows that $c = a_1 a_2 \boldsymbol{R}_1 \boldsymbol{R}_2 \boldsymbol{c}$, $\boldsymbol{p} = a_1 a_2 \boldsymbol{R}_2 \boldsymbol{R}_1 \boldsymbol{p}$. Thus, the EEC of the region is defined as the eigenvector of the matrix$\boldsymbol{R}_1 \boldsymbol{R}_2$, and the EEC of TEA is defined as the eigenvector of the matrix$\boldsymbol{R}_2 \boldsymbol{R}_1$. The matrices $\boldsymbol{R}_1 \boldsymbol{R}_2$and $\boldsymbol{R}_2 \boldsymbol{R}_1$are stochastic: their elements are non-negative, and their row sum is 1. Due to stochasticity, the matrix $\boldsymbol{R}_1 \boldsymbol{R}_2$has an eigenvalue equal to 1 and an eigenvector corresponding to it, which consists of identical coordinates. In the works (Hausmann, Rodrik, 2003; Sciarra et al., 2020), it is proposed to use the values of the eigenvector of the matrix $\boldsymbol{R}_1 \boldsymbol{R}_2$as the values of the EEC of the regions, which correspond to the second maximum eigenvalue.

3`STUDY RESULTS

When calculating the EEC of the regions according to TEA, the indicators of industrial production for four enlarged types of economic activity, as well as the structure of the volumes of shipped products, were used. As a result, according to the Federal State Statistics Service for 2019, the volumes of shipped goods, completed works and services for 24 TEA were obtained for Russian regions (Afanasiev, Gusev, 2023). The structures of strong TEA and EEC of the regions by TEA are calculated. A comparative analysis of EEC of the regions by sector and TEA allows us to conclude that EEC of the regions have high stability in the transition from data on tax revenues to data on production volumes and from data on sectors to data on TEA (Afanasiev, Gusev, 2023).

The correlation coefficient of estimates of the economic complexity of 79 regions in 82 sectors and 24 TEA according to data for 2019 is 0.771. The procedure for preparing initial information for calculating the EEC of the regions by TEA is simpler than by sectors. Therefore, the possibility of econometric modeling of EEC by sector using EEC by TEA and the main components of the structure of production volumes for TEA is of particular interest. These main components are calculated similarly to how the main components of the GRP industry structure are constructed in (Ayvazian et al., 2016). The following three summary indicators were used. F1 is the share of the total production volume for four TEA in GRP: "Coal Mining", "Metal Ore Mining", "Mining of Other Minerals", "Provision of Services in the Field of Mining". F2 is the share of the volume of production by TEA "Oil and Natural Gas Production" in GRP. F3 is the share of the total production volume for three enlarged TEA in GRP: "Manufacturing" (12 TEA); "Provision of Electric Energy, Gas and Steam; Air Conditioning" (3 TEA); "Water Supply; Sanitation, Waste Collection and Disposal, Pollution Elimination Activities" (4 TEA). Based on the data on these three indicators for 2019, three main components were calculated. The total proportion of variance explained by the first g1 and second g2 of main components is 97.9%.

4 RESULT DISCUSSION

Factor loads for the first fg1 and second fg2 of main components are shown in Table 1. The first main component divides regions with developed TEA in mining (high positive correlation with indicators F1 and F2, characterizing all TEA related to mining) and other regions (high negative correlation with indicator F3, characterizing all other TEA). The second main component divides regions with developed TEA "Oil and Natural Gas Production" (high negative correlation with F2); regions with developed TEA "Coal Mining"; "Metal Ore Mining"; "Mining of Other Minerals"; "Provision of Services in the Field of Mining" (high positive correlation with F1) and regions that do not specialize in TEA related to mining (close to zero correlation with F3).

Table 1: Factor loads.

Indicators	fg1	fg2
F1	0.7578	0.6394
F2	0.6569	-0.7453
F3	-0.9837	-0.0057

Source: Authors' calculations.

Figure 1 shows 79 regions in the space of the first two main components. In the first orthant with positive coordinates for the first and second main components, the points correspond to regions with relatively highly developed TEA "Coal Mining"; "Metal Ore Mining"; "Mining of Other Minerals"; "Provision of Services in the Field of Mining". In the orthant with positive coordinates for the first and negative coordinates for the second main component, the points correspond to regions with relatively highly developed TEA "Oil and Natural Gas Production". In

the left part of the figure, with negative coordinates for the first and with coordinates close to zero for the second main component, the points correspond to regions that do not specialize in TEA related to mining. A special position in the right part of the figure with the coordinate on the first main component close to 4 and on the second – close to 0 is occupied by the point corresponding to the region of the Republic of Sakha (Yakutia).

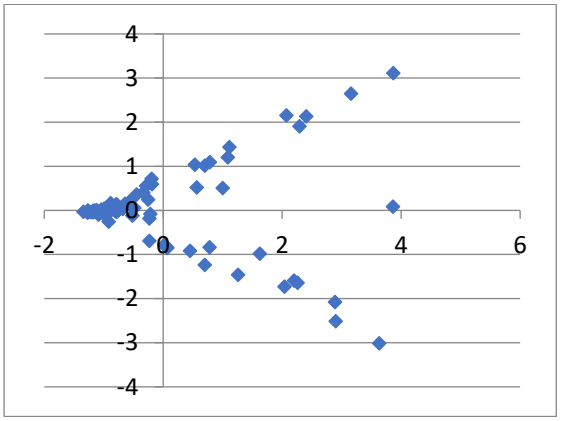

Figure 1: Regions in the space of the first two main components of the GRP structure by TEA. Source: Authors' calculations.

Table 2 shows the estimates according to the 2019 data of the regional EEC regression by sectors ECI_k^s into three explanatory variables: EEC of the regions according to ECI_k, the first g1 and the second g2 are the main components of the structure of the economy according to TEA. All explanatory variables are significant at the level 5%. The coefficient of determination R^2 =0.737 indicates that the correlation of the actual and expected values of the economic complexity of the regions by sector exceeds 0.85.

Table 2: Regression coefficients ECI_k^s.

Explanatory variables	Coefficient	P>t
ECI_k	.6769	0
g1	-.1519	0.034
g2	.3002	0
_cons	-.0314	0.527

Source: Authors' calculations.

The results obtained confirm the possibility of constructing a model for forecasting ECI_k^s of the regions by economic sectors using ECI_k of the regions by TEA and the main components of the structure of the economy by TEA.

5 CONCLUSION

Estimates of economic complexity remain highly stable during the transition from data on sectors to data on types of economic activity (TEA). Estimates of the regression of the index of economic complexity of regions by economic sectors into three explanatory variables are presented: the index of economic complexity of regions by TEA, the first and second main components of the structure of the economy by TEA. All explanatory variables are significant at the level 5%. The correlation of actual and expected values of estimates of the economic complexity of regions by sector exceeds 0.85. The results obtained confirm the possibility of constructing a model for forecasting EEC of the regions by sectors using EEC of regions by TEA and the main components of the structure of the economy by TEA.

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