Formation of Indicators of the Development of Production Potential and the Level of Socio-Economic Development of the Region

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Abstract. The functioning of any complex system is usually assessed by observable parameters that are obvious to the researcher. Depending on the complexity of the system, there can be a fairly large number of such parameters (indicators) that can be measured based on existing measurement systems (scales). This is especially true for complex socio-economic systems. In this regard, at least two main tasks arise: how to determine the state and dynamics of the entire system as a whole and what is the influence and mutual influence of the elements of the system among themselves. One of such complex elements is the production potential of the region, the state and dynamics of which cannot be directly assessed. Usually, to assess it, indices, regression relationships, and an assessment of its main components (primary indicators) are used. This article discusses an approach based on the assessment of production potential using indicators derived from factor analysis. Factor analysis makes it possible to reduce the number of observed features (indicators included in the assessment of production potential) by searching for a smaller number of hidden (latent) factors (we called them indicators). The same approach was used to search for indicators reflecting the socio-economic development of the region. The article also examines the impact of the level of development of production potential on the socio-economic development of the region. At the same time, primary statistical indicators processed using factor analysis were used as the basis of the evidence base. Identified indicators reflecting the development of individual components of production potential. A rating assessment of the regions of the Central Federal District was carried out according to the proposed indicators.

1. Introduction

Economic research is often based on the analysis and evaluation of statistical indicators. Official statistics record a fairly large number of different indicators. One of the problems in identifying trends in the development of industries, regions, economic complexes is the interpretation of changes in primary statistical indicators. Changes can be directed in different directions, both positive and negative. Then the question arises about the degree of importance of each primary statistical indicator, or the question of creating an integral index, which can be used to judge the dynamics of a larger
object, for example, the economy of a particular region. The second problem is to determine how accurately the measured indicators reflect the state and development of this object, whether the collected statistical data are exhaustive, whether there are other, not yet recorded indicators that can better assess the state and development of the object. These problems become more obvious when trying to create relationships between economic phenomena and objects, that is, when we try to determine the conjugate or interdependent development of two or more objects, phenomena or processes. In addition, the observed indicators, although convenient for further processing, may not reflect the causes of economic phenomena that cause a change in the observed indicator and fix its value for a specific date or for a specific period of time. The identification of such reasons (factors) is interesting and lies in the field of factor analysis. When they are detected, it is possible to assess the relationship between economic phenomena, objects not by observed values, but by indicators formed from factor variables (loads).

2. Materials and methods

It should be noted that the problems of assessing the state and development of complex objects and systems, such as the production potential of a region or an enterprise, with the use of integral indices or without them, were solved by many scientists. For example, V.O. Glushko, E.V. Kocheva, N.V. Zornikova [6] proposed an integral indicator of the production potential of Russia and its constituent entities based on indicators combined into several blocks. Arkhipova L.S., Kulikova E.I., Ilina A.I. [1] assessed the production potential of Russian regions using a group of primary statistical indicators without combining them into an index. O. Karsuntseva [9] used the method of multivariate cluster analysis to assess the production potential of an industrial enterprise and create a corresponding integral index. Gagarina G.Yu. and Arkhipova L.S. [5] assessed the economic potential of the macroregion as a factor in the stability of the Russian economy. Tsenina E. et al. [21] assess the economic potential of the region and propose to use game theory when conducting a comprehensive assessment of the economic potential of the region in order to identify the specialization of the region and determine the strengths and weaknesses of its development. The author's methods for assessing the production potential of the regions of Russia and Russia as a whole were proposed by S.A. Ayyazy, and collaborators [2, 3, 11].

Researchers often don’t consider production potential as a separate object, but include it in the potential of a higher level - in the economic one (Nikiforova V.D., Nikiforov A.A. [12], Selisheeva T.A. [16], Rokchin V.E., Neustroev S.S. [15]). Some do not consider production potential, replacing it with resource potential, especially when it comes to the level of an individual economic entity or their group. For example, Ilina E., Velm M. [8] assessed not production, but resource potential at the level of the production system using expert assessments.

It should be noted that the method of factor analysis was also used by researchers at the regional level. Shen Lei-ming, XU Mei ’, Wang Fu-lin, Zhang Hao [17] used factor analysis to comprehensively assess the economy of one of the provinces of China, obtaining common factors for a group of initial variables. Olsen B. & Garb G. [14] used factor analysis to estimate regional economic growth. M. Gil, D. Leiva-Leon, J.J. Pérez & A. Urtasun [10] used dynamic factor models to estimate regional economic activity in Spain. S. Beugelsdijka, M.J. Klasingb & P. Milionisc [18] highlighted factors in terms of overall factor productivity (TFP) in Europe.

When studying complex objects and systems, it is impossible to directly determine the so-called factors affecting the change in the properties of these objects, obtained in the sampling process, and sometimes even the number and meaning of the factors are not known [13]. Other quantities may be available for measurements, depending in one way or another on these factors. Analysis shows that the unknown factor manifests itself in a change in several features. These signs reveal a close connection with each other, manifested in their correlation [7]. Therefore, the total number of factors is much less than the number of measured variables (54 indicators were used in the present study) and these factors are not arbitrary, but are considered as relevant and reliable indicators of real socio-economic processes.
Our work as well as the previous ones was aimed at researching the production potential of a particular region - the Central Federal District (CFD) and the regions included in it [19,20]. In addition to identifying indicators of production potential, we tested the hypothesis about the relationship between the level of development of production potential and the level of socio-economic development in the studied regions of the Central Federal District. At the same time, indicators of production potential and indicators of socio-economic development were determined using factor analysis, without using methods for converting primary statistical indicators into integral indices.

The use of factor analysis makes it possible to identify and explain the meaningful meaning of the main factors formed by subsets of individual indicators, which are their various features (in our case, forming a central group of characteristics of production potential and three classification groups of characteristics of socio-economic development of regions of the Central Federal District). Obviously, the numerical values of the relevant factors form a system of indicators that make it possible to perform and compare an objective rating assessment of the level of production potential with the data of the rating assessment of the socio-economic development of the regions of the Central Federal District. It should be borne in mind that cluster analysis does not contain a computational mechanism for testing the hypothesis about the adequacy of the obtained classifications, and the clustering results must be substantiated by the methods of factor analysis.

The fundamental importance for determining the impact of the level of development of production potential on socio-economic development is the formation and component analysis of indicators of the production potential of the regions of the Central Federal District (Table 1).

Table 1. Factorial matrix of variables that form a group of indicators of the level of development of the production potential of the regions of the Central Federal District.

| Variable | Factors | F2 | F3 |
|----------|---------|----|----|
|          | F1      |    |    |
| Factor loadings on variables |         |    |    |
| X41      | 0.96    | 0.23 | -0.01 |
| X42      | 0.79    | -0.18 | -0.14 |
| X44      | 0.91    | 0.34 | 0.02 |
| X45      | 0.04    | -0.17 | 0.96 |
| X47      | 0.94    | 0.20 | 0.08 |
| X53      | 0.89    | 0.37 | -0.05 |
| X54      | 0.92    | 0.02 | 0.18 |
| X55      | 0.72    | 0.90 | -0.20 |
| X61      | 0.21    | 0.24 | 0.01 |
| X72      | 0.94    | 0.21 | 0.01 |

Note that the degree of significance of the impact of factors on the level of the production potential of the regions in this group (as in all classification groups) of indicators decreases in ascending order of their numbers: factor F1 is the most significant and significant, the next factor in terms of impact on production potential is factor F2, the least significant factor is F3.

In the case of orthogonality of the vector representation of factors and the absence of multicollinearity of variables, factor loadings are expressed by the correlation coefficients between factors and variables, the values of which are in the range from 0 to + (-) 1, the corresponding sign determines the directly or inversely proportional dependence of the change in the indicator and the value of the factor, which in further considered and called an indicator. The corresponding variables are recognized as significant for the formation of the indicator if their factor loadings are not less than 0.6 in absolute value.
In the group of indicators of the level of development of production potential, the main significant and interrelated signs of the potential of regional production form an indicator expressed by the factor F1.

All indicators corresponding to these characteristics have high positive values of factor loadings. Based on the analysis of the composition of significant variables, which forms the factor F1 (Table 2), let us define it as an “Indicator of the scale of production potential”.

**Table 2.** The content of indicators in the group of indicators of the level of development of the production potential of the regions of the Central Federal District.

| Variable | Index | Factor loading sign |
|----------|-------|---------------------|
| X41      | Gross regional product | + |
| X42      | Gross regional product per capita | + |
| X44      | Number of enterprises | + |
| X53      | Production of reinforced concrete building structures | + |
| X54      | Residential buildings commissioning | + |
| X72      | Fixed capital investments | + |
| X55      | Power generation | + |

**Indicator expressed by factor F1**

**Indicator expressed by factor F2**

**Indicator expressed by factor F3**

X45 Mining and manufacturing +

Once again, we note that factors are interpreted by us as indicators with specific numerical characteristics, qualitative content, determined by the composition of the variables (indicators) included in it.

In the group of indicators of the level of production potential, the next most significant factor is F2, which is formed by the only variable expressing the production of electricity as an energy basis for industry, construction, and agriculture. This factor should be defined as the "Indicator of the region's electricity potential". Factor F3 determines the scale of the regional raw material production potential, since it includes the only variable that expresses mining and manufacturing. This factor is defined as the "Indicator for the extraction and processing of raw materials." Thus, we have identified three main indicators that form production potential.

The most important achievement of factor analysis is the ability to quantify the indicators of the studied economic phenomenon, what is the level of development of the production potential of the subjects of the Central Federal District. This is achieved with the help of the corresponding partial for individual factors and generalized for all significant factors integral numerical characteristics that form individual and general indicators of the corresponding classification group of socio-economic indicators. These characteristics make it possible to form an objective rating assessment of the regions of the Central Federal District, which is necessary for making effective management decisions on the choice of priorities in the development of production potential and the accompanying increase in the level of socio-economic development. Table 3 shows the values of the factors (considered as indicators of the level of the production potential of the regions of the Central Federal District), which were obtained by the method of principal components. The corresponding values of the factors can have positive or negative signs and are necessary for ranking the regions according to the corresponding indicators and predicting the normative values of the indicators that form individual factors.
Table 3. General and specific indicators of the level of production potential of the subjects of the Central Federal District (according to factor analysis).

| Region serial number | Region name   | Private indicators expressed by factors: | General indicator |
|----------------------|---------------|------------------------------------------|-------------------|
|                      |               | F1 | F2   | F3 |                |
| 1                    | Belgorodskaya | 2.00 | -0.97 | 0.74 | 1.77 |
| 2                    | Bryansk      | -3.50 | -1.40 | 0.70 | -4.20 |
| 3                    | Vladimirskaya| -0.23 | -0.79 | 0.31 | -0.70 |
| 4                    | Voronezh     | 2.40 | 1.09 | 0.09 | 3.58 |
| 5                    | Ivanovskaya  | -4.49 | -1.01 | -0.50 | -6.00 |
| 6                    | Kaluga       | -1.53 | -1.86 | 3.09 | -0.30 |
| 7                    | Kostroma     | -4.51 | -0.44 | -0.48 | -5.43 |
| 8                    | Kursk        | -2.77 | 0.72 | -0.50 | -2.55 |
| 9                    | Lipetsk      | 0.95 | -1.00 | -0.57 | -0.62 |
| 10                   | Moscow       | 25.90 | 7.08 | 0.00 | 35.98 |
| 11                   | Orlovskaya   | -3.63 | -1.16 | -0.53 | -5.32 |
| 12                   | Ryazan       | -1.76 | 0.08 | -0.62 | -2.30 |
| 13                   | Smolensk     | -1.82 | 1.12 | -0.92 | -1.62 |
| 14                   | Tambov       | -4.31 | -1.4 | -0.39 | -6.10 |
| 15                   | Tverskaya    | -0.59 | 1.65 | -0.60 | 0.46 |
| 16                   | Tula         | -1.48 | -0.89 | 1.80 | -0.57 |
| 17                   | Yaroslavl    | -0.60 | -0.80 | -0.72 | -2.12 |

3. Results and discussion
The methodology discussed above allows one to obtain the values of factor variables (factor loadings), on the basis of which it is possible to rank regions both by the level of private indicators of production potential, and by the level of the general indicator obtained by summing the values of particular indicators (Table 4). This allows you to determine the level of development of the production potential of a particular region in their totality and understand in which direction it is necessary to make decisions to increase the level of production potential.

Table 4. Ranked series of indicators of the level of production potential of the subjects of the Central Federal District (according to factor analysis).

| Region serial number | Region name   | Ranked ranks of occupied places |
|----------------------|---------------|---------------------------------|
|                      |               | Private indicators expressed by factors: | By a common indicator |
|                      |               | F1 | F2   | F3 |                     |
| 1                    | Belgorodskaya | 3 | 11   | 3 | 3 |
| 2                    | Bryansk      | 13 | 15   | 4 | 13 |
| 3                    | Vladimirskaya| 5 | 8    | 5 | 8 |
| 4                    | Voronezh     | 2 | 4    | 6 | 2 |
| 5                    | Ivanovskaya  | 17 | 13   | 11 | 16 |
| 6                    | Kaluga       | 9 | 17   | 1 | 5 |
| 7                    | Kostroma     | 16 | 7    | 9 | 15 |
| 8                    | Kursk        | 12 | 5    | 10 | 12 |
| 9                    | Lipetsk      | 4 | 12   | 13 | 7 |
| 10                   | Moscow       | 1 | 1    | 7 | 1 |
| 11                   | Orlovskaya   | 14 | 14   | 12 | 14 |
| 12                   | Ryazan       | 10 | 6    | 15 | 10 |
Carrying out the same calculations for the primary indicators characterizing the social development of the region (we have identified three groups: demography and employment; living standards; health care, education and human rights protection), it is possible to identify the causal correspondence of socio-economic development to the level of development of production potential. Let us consider the formation of indicators in the selected classification groups of indicators of socio-economic development in the regions of the Central Federal District, reflecting the demography and employment of the population; standards of living; level of health care, education and criminalization.

The final results for the three blocks are presented in Table 5.

Table 5. Ranked series of the level of socio-economic development in the regions of the Central Federal District by general indicators.

| Number | Central District | Federal Demographics and employment | Standard living | Health education, rights | care, human |
|--------|------------------|------------------------------------|-----------------|---------------------------|------------|
| 1      | Belgorodskaya    | 2                                  | 2               | 11                        |            |
| 2      | Bryansk          | 6                                  | 13              | 10                        |            |
| 3      | Vladimirskaya    | 7                                  | 15              | 12                        |            |
| 4      | Voronezh         | 3                                  | 4               | 2                         |            |
| 5      | Ivanovskaya      | 14                                 | 17              | 9                         |            |
| 6      | Kaluga           | 13                                 | 11              | 14                        |            |
| 7      | Kostroma         | 12                                 | 3               | 17                        |            |
| 8      | Kursk            | 9                                  | 6               | 7                         |            |
| 9      | Lipetsk          | 5                                  | 7               | 13                        |            |
| 10     | Moscow           | 1                                  | 1               | 1                         |            |
| 11     | Orlovskaya       | 8                                  | 14              | 15                        |            |
| 12     | Ryazan           | 10                                 | 9               | 8                         |            |
| 13     | Smolensk         | 15                                 | 12              | 6                         |            |
| 14     | Tambov           | 11                                 | 10              | 3                         |            |
| 15     | Tverskaya        | 16                                 | 5               | 5                         |            |
| 16     | Tula             | 17                                 | 16              | 16                        |            |
| 17     | Yaroslavl        | 4                                  | 8               | 4                         |            |

If we sum up the factor loadings for the general indicators of these three blocks (demography and employment; living standards; health care, education and human rights protection), and rank the regions according to the value of the factors, we will get the “places” of each region in terms of socio-economic development. Comparison of the region's places (ranks) in terms of the level of development of production potential and the level of socio-economic development (in the study, we focused on the primary indicators of social development) can be clearly shown in Figure 1.
Figure 1. Comparison of regions in terms of the level of development of production potential and socio-economic development.

The figure shows that most of the regions (in the study of 17 regions) are located along the main diagonal (in the figure - the orange oval), which shows the exact coincidence of the region's place in terms of the level of development of production potential and indicators of socio-economic development. Only 5 regions lie away from the main diagonal (gray ovals in the picture).

4. Conclusion
The results obtained allow us to conclude that there is a direct dependence of the level of socio-economic development of the studied regions on the level of production potential. This conclusion was obtained on the basis of comparing the rating places of the regions in terms of the level of socio-economic development (three blocks) and the level of production potential. We ran the ranking on the basis of the obtained values of indicators - factor loads formed on the basis of the use of the principal component method in relation to the primary observed statistical indicators. The use and comparison of primary statistical indicators cannot give such conclusions, since these indicators change in diametrically opposite directions. Simple regression relationships between them cannot be informative either (this is why integral indicators are often used). Factor analysis, in turn, makes it possible not to use integral indices, but to operate with factor loads, which can serve as a kind of indicators of both the level of production potential and the level of socio-economic development.

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