# APPLICATION OF SOME STATISTICAL METHODS OF CONSTRUCTION OF INTEGRATED INDICATORS FOR AN ASSESSMENT OF DIFFERENCES OF SOCIAL AND ECONOMIC SITUATION OF REGIONS

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**Abstract**

The socio-economic development of a country depends on the socio-economic situation of its regions. Understanding the situation in the regions is a necessary element in the formation of the socio-economic policy of the state aimed at reducing the differentiation of territories, timely warning of the danger of increasing territorial differentiation in the standard of living of the population. The article discusses the possibility of using integrated indicators to assess the differentiation of regions by social and economic situation, on the example of the regions of the Russian Federation. Since integrated indicators allow to summarize the information contained in a variety of indicators that characterize the economy and social sphere of the region. Two methods are used in the construction of integral indicators: the method of equal weights and the method of principal components. A comparative analysis of the results of the methods is carried out. The relationship between the regional rankings on economic and social position was analysed.

**Key words:** regional disparities, the integrated indicators, the principal components method, the equal weights method

**JEL Code:** R12, R15

## Introduction

The priority tasks of the state policy are to reduce the territorial differentiation according to the main social and economic indicators and to ensure the equality of citizens ' rights guaranteed by the Constitution of the Russian Federation and equal opportunities in their implementation.

The Russian Federation is characterized by a large area of territory divided into 85 equal subjects of the Russian Federation with their Executive, legislative and judicial powers. Subjects of the Russian Federation are characterized by a variety of climatic conditions, the

structure of the economy, the national composition. The generalized assessment of the socio-economic situation of the Russian Federation does not reveal the peculiarities of the state of individual regions, which prevents the formation of an effective socio-economic state policy. Therefore, in the framework of our study, the analysis is carried out taking into account the territorial differentiation of social and economic indicators. Taking into account the differences in the economic and social processes of the subjects of the Federation makes it possible to identify changes in the territorial and sectoral structure of the economy of the regions, to identify problem regions, to warn in a timely manner about the danger of increasing territorial differentiation in living standards.

The analysis of territorial differentiation is carried out on the basis of a set of indicators characterizing various aspects of social and economic systems.

The advantage of this approach is the possibility of in-depth and comprehensive study of various components of social and economic regional processes. The disadvantages include the complexity of the analysis, the redundancy of information, the problematic comparative analysis of territories. Therefore, for a comprehensive assessment of the socio-economic situation, it is possible to use the construction of aggregated integrated indicators of social and economic development of the regions. The Russian statistics has not yet developed a unified methodological approach to the determination of weights of indicators of the initial characteristic space for the construction of an integral indicator of regional disparities. Therefore there is a problem of a choice of a method of determination of weights of indicators.

Methods for estimating weights of indicators can be classified into subjective, objective and combined methods, see for example: Ginevičius, Podvezko, 2005; Zou, Yun and Sun, 2006; Zardari, Ahmed, Shirazi and Yusob, 2015; Zmeškal, Dluhošová, 2015. In objective methods, weights are obtained by mathematical methods. Objective methods include the Equal weights method, Entropy method, Principal Component method, standard deviation or statistical variance procedure, etc. (Ayvazyan, 2000; Zardari, Ahmed, Shirazi and Yusob, 2015; Ginevičius and Podvezko, 2005; Tzeng and Huang, 2011; Minarčíková, 2016). In the use of subjective weighting methods, the process of assigning importance to criteria depends on the preferences of decision-makers, to these methods belong e.g. direct rating, ranking method, point allocation, pairwise comparison, swing method, Delphi method (Zardari, Ahmed, Shirazi and Yusob, 2015). The study proposes the use of two objective methods: Equal Weights Method and the Principal Components Method.

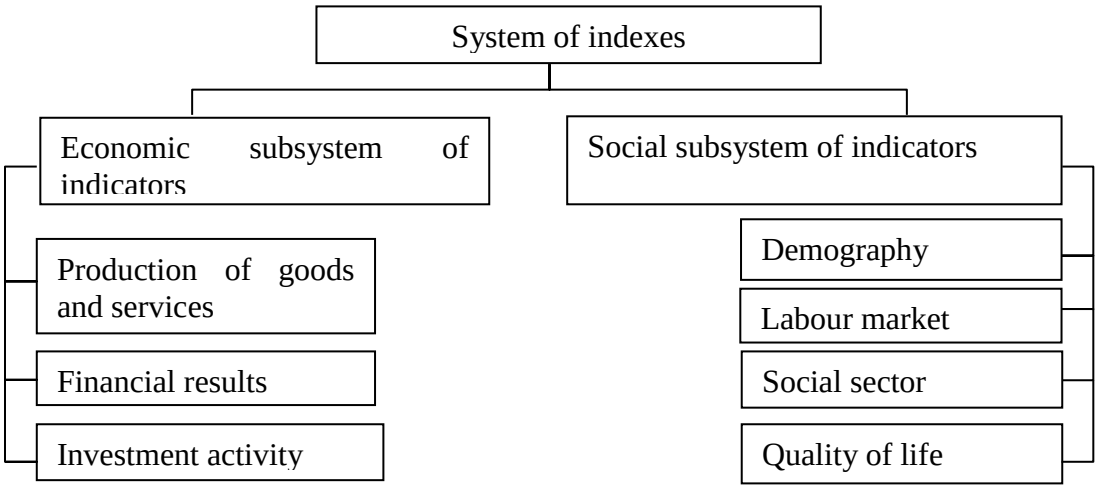
In the Equal Weights Method, the integral index is calculated as the arithmetic mean of the pre-normalized values of the of the initial parameters. Since the indicators are taken with equal weights, the impact of the indicators on the result will be the same. The advantages of this approach include the simplicity of calculations and interpretation of the result.

The principal components method is based on accounting for the variance of the initial features: the weight coefficients are estimated as a result of the transformation of the initial high-dimensional data space based on data variance information. That is, the weight of the initial indicator depends on the degree of dispersion of its values. The values of the first main component are taken as the values of the integral indicator (Ayvazyan, 2000; Makarov, Ayvazyan, Afanasyev, Bakhtizin, & Nanavyan, 2014).

## Research methods

For the study of social and economic processes of the regions, a system of indicators was formed, the structure of which is shown in figure 1, including indicators characterizing the social and economic aspects of the situation of the regions. Since inter-territorial comparisons are carried out, specific indicators calculated per capita or the number of employed in the economy are considered to eliminate the influence of the scale of the region. When developing the system of indicators, the availability of data published by the Federal and Territorial state statistics service and posted on the websites of the services was taken into account.

**Fig. 1: Structure of the system of indicators of social and economic development of regions**




Source: author's own work

Economic subsystem of indicators (tab.1) includes regional indicators characterizing the production of goods, services, financial results of enterprises and organizations, investment activities.

**Tab.1: Indicators of the economic situation of the regions of the Russian Federation**

| | |
|---|---|
| X1 | Gross regional product, million rubles per thousand employed in the economy |
| X2 | Net financial result of organizations, million rubles per thousand employed in the economy |
| X3 | Fixed assets in the economy at full book value; at the end of the year, million rubles per thousand employed in the economy |
| X4 | The revenues of the consolidated budgets of the constituent entities of the Russian Federation, mln. RUB. per thousand employees in the economy |
| X5 | Investments in fixed capital, million rubles per thousand employed in the economy |

Source: author's own work

Social subsystem of indicators (tab.2) includes indicators characterizing demographic processes, labor market, social sphere and standard of living.

**Tab.2: Indicators of the social situation of regions of the Russian Federation**

| | |
|---|---|
| X6 | Cash income per capita per month, rubles per Capita cash income per month, rubles |
| X7 | Consumer spending on average per capita per month, rubles |
| X8 | The population with monetary income is below the subsistence minimum, as a percentage of the total population of the subject |
| X9 | Share of household expenditure on housing and communal services, as a percentage of total consumer expenditure |
| X10 | Life expectancy at birth, number of years |
| X11 | The coefficients of the net migration rate, per 10,000 population |
| X12 | Employment rate of the population aged 15-72 |
| X13 | Coverage of children in pre-school education, as a percentage of the number of children of the appropriate age |
| X14 | Number of students enrolled in bachelor's, specialist's and master's programs per 10 000 population |
| X15 | Number of registered crimes, per 100,000 population |
| X16 | Emissions of pollutants into the air from stationary sources, tons per $km^2$ |

Source: author's own work

Database for the regions of the Russian Federation for 2017 was formed on the basis of a system of indicators.

To eliminate the influence of the dimension of the values of indicators and the direction of change of values from the best state of the object to the worst, we have moved to

the unified values of indicators. Each of the unified indicators $I_i$ is calculated on the basis of the corresponding indicator $X_i$ by formulas (Ayvazyan, 2000):
for the case when higher values of the indicator correspond to the worst state

$$I_{ij} = (x_{ij} - x_{i\,min})/(x_{i\,max} - x_{i\,min}) \;;$$

or for the case when the lower values of the indicator correspond to the worse state

$$I_{ij} = (x_{i\,max} - x_{ij})/(x_{i\,max} - x_{i\,min})$$

where $x_{ij}$ – actual value of j-observation for i-th indicator ;

$x_{i\,max}$, $x_{i\,min}$ – accordingly, the maximum and minimum value of the i-th indicator.

To compare the social and economic situation of the regions of the Russian Federation and determine the degree of their differentiation, an integral indicator of the social situation of the regions of the Russian Federation (II SSR) and an integral indicator of the economic situation of the regions (II ESR) for 2017 were constructed.

II ESP combines the influence of the 5 indicators (X1-X5), characterizing the production of goods and services, without regard to sectoral focus, financial results of activity of enterprises and organizations, the investment activity of the regions.

II SSR combines the influence of 11 indicators (X6-X16) characterizing demographic processes, labor market, social sphere and living standards of territories.

Integral indicators were constructed using two methods.

*First method.* In the Equal weights method, the integral index was constructed as the arithmetic mean of the unified values of these indicators:

$$II\,ESR' = (I_1 + \ldots + I_5)/5 \;;$$

$$II\,SSR' = (I_6 + \ldots + I_{16})/11.$$

The smaller the value of the integral indicator, the better the state of the integral indicator is typical for the region.

*Second method.* When using the principal component method, the integral index is calculated according to the algorithm for determining the values of the first principal component (Lai, 2003; McKenzie, 2005).

Further, after calculations by both methods, to facilitate the interpretation of the integral indicators were unified by the formula:

$$II_j = (II'_{ij} - II'_{min})/(II'_{max} - II'_{min}) .$$

After unification, the values of the integral indicator will be distributed in the interval [0; 1], where the value 0 will correspond to the best state of the integral indicator for the region, 1 - the worst state.

## Research result

On the basis of the methodology outlined above, calculations of integral indicators were carried out. Comparison of the results of the construction of integrated indicators by two methods (the Equal weights method and the principal components method) showed that the values of integrated indicators are similar: the correlation coefficient between the integral indicators of social development is 0.79, and between the integral indicators of economic development is 0.98. It should be noted that when using the principal component method, indicators for II SSR received more weight: X1 – gross regional product, X3 – the cost of fixed assets, X5 – the volume of investment; for II ESR: X6 – per capita income, X7 – consumer spending, X8 – the share of the population with incomes below the subsistence minimum, X12 – the level of employment. In both cases (II SSR, II ESR), the first principal component explains more than 55% of the variation of the initial high-dimensional data space. Therefore, the values of the integral indicator will be equal to the values of the first main component calculated for each region.

The results of the construction of integrated indicators and ranks by region leaders and regions outsiders by two methods are presented in table 3.

In the ranking of social status (II SSR) the leading position is occupied by the city of Federal importance - Moscow, there is a prosperous situation in almost all social indicators. At the same time, Moscow is among the leaders in terms of economic indicators. The Republic of Tuva occupies the last place in the ranking of regions by social status, this is due to low income, unemployment, high crime.

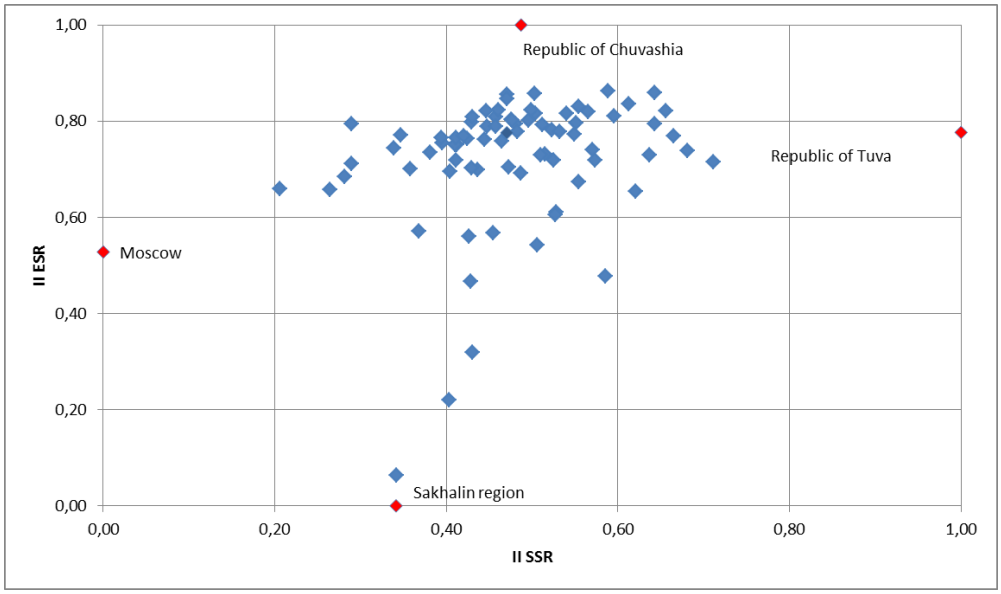
Further, on the basis of II ESR and II SSR, constructed using the Equal weights method, a diagram of their mutual distribution (fig. 2), allowing to analyze the interdependence of integrated indicators. The point with coordinates (0;0) corresponds to the best state of the social sphere, the standard of living, as well as the best state of the economy. The point with coordinates (1;1) corresponds to the worst social and economic condition.

**Tab. 3: Integral indicators of the economic situation (II ESR) and social (II SSR) regions of the Russian Federation and the ranking of regions**

| Region | Equal weights method | | | | Principal component method | | | |
|---|---|---|---|---|---|---|---|---|
| | ESR | | SSR | | EPR | | SSR | |
| | II | Rang | II | Rang | II | Rang | II | Rang |
| Moscow | 0,53 | 7 | 0 | 1 | 0,53 | 7 | 0 | 1 |
| Saint-Petersburg | 0,66 | 16 | 0,21 | 2 | 0,66 | 16 | 0,02 | 2 |
| Republic of Tatarstan | 0,66 | 15 | 0,26 | 3 | 0,66 | 15 | 0,38 | 13 |
| Moscow Region | 0,68 | 18 | 0,28 | 4 | 0,69 | 18 | 0,24 | 6 |
| Sevastopol | 0,79 | 57 | 0,29 | 5 | 0,80 | 60 | 0,54 | 46 |
| Belgorod Region | 0,71 | 25 | 0,29 | 6 | 0,71 | 25 | 0,41 | 17 |
| Voronezh Region | 0,74 | 36 | 0,34 | 7 | 0,74 | 36 | 0,44 | 21 |
| Sakhalin Region | 0 | 1 | 0,34 | 8 | 0,00 | 1 | 0,23 | 5 |
| Tyumen Region | 0,06 | 2 | 0,34 | 9 | 0,05 | 2 | 0,34 | 9 |
| …… | | | | | | | | |
| Kurgan region | 0,86 | 80 | 0,64 | 76 | 0,86 | 79 | 0,70 | 75 |
| Republic of Buryatia | 0,79 | 59 | 0,64 | 77 | 0,80 | 59 | 0,64 | 68 |
| Karachay-Cherkess Republic | 0,82 | 71 | 0,66 | 78 | 0,82 | 73 | 0,80 | 79 |
| Trans-Baikal Territory | 0,77 | 45 | 0,67 | 79 | 0,77 | 45 | 0,70 | 76 |
| Republic of Altai | 0,74 | 34 | 0,68 | 80 | 0,74 | 35 | 0,80 | 78 |
| Jewish Autonomous Region | 0,72 | 26 | 0,71 | 81 | 0,71 | 26 | 0,68 | 73 |
| Republic of Tuva | 0,78 | 50 | 1 | 82 | 0,78 | 53 | 1,00 | 82 |

Source: author's own work

**Fig. 2: Diagram for mutual distribution II SSR and II ESR**




Source: author's own work

Referring to this diagram, it can be noted that there is a significant differentiation between regions in terms of social status. At the same time, economically prosperous regions have somewhat better indicators of social status. It can also be noted that the spread of II ESR values is almost two times smaller (mean square deviation 0.067) than II SSR (mean square deviation 0.12). This suggests that in terms of economic efficiency, the regions are more homogeneous than in terms of social indicators. High differentiation in social indicators leads to social tension, the outflow of the population from the regions of outsiders, and as a consequence, to problems in the economy associated with an insufficient number of labor resources.

## Conclusion

According to the results of the study, the following conclusions can be made:

• the Equal weights method and principal component method yielded similar results in the construction of integral indicators. Since the Equal weights method is easier to use, does not require the use of special application software and the results are much easier to interpret in comparison, it can be recommended to use the Equal weights method in similar problems;

• there is a higher differentiation of regions in social indicators than in the efficiency of the economy. High differentiation in social indicators leads to social tension, the outflow of the population from the regions of outsiders, and as a consequence, to problems in the economy associated with an insufficient number of labor resources.

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