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Research paper

Statistical Toolkit for Assessing the Financial Security of Regions

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Abstract

Each stage of the statistical research of economic and financial security requires the use of another extensive block of statistical toolkit represented by methods of general theory of statistics and mathematical statistics, including multidimensional groupings – cluster analysis, correlation and regression methods. This scientific article is devoted to such a statistical toolkit and analytical capabilities for its application in the research into the financial security of the region, where the financial security of the Moscow region, described by a range of financial and economic indicators, is the subject of statistical research.

Keywords: *Cluster analysis, regression method, Dianov metrics, multidimensional grouping, financial security of regions*

1. Introduction

Economic zoning, placement of productive forces, financial and economic ties, inconceivable range of economic activities, peculiarities of economic relations of institutional units, demographic and natural resource potential, as well as the entire economic geography of the Russian Federation in general are so diverse that it is impossible in the absolute majority of cases, less often – difficult, and sometimes even absurd to paint the whole set of Russian regions with a single brush when modeling social and economic processes. This is about a numerical base – the source data, in respect of which a decision must be made, – or about their unification into a single array following the results of a statistical summary, or, on the contrary, about the inexpediency of such enlargement [1]. At the same time, the study of each region or a group of Russian regions must be subordinated to methodological unity in terms of carrying out a complex statistical analysis of the object or phenomenon inherent in the society under study.

2. Justification of Application of Statistical Methods for Monitoring Regional Processes

According to the theory of statistics, the first stage of the statistical research is the collection of information about the object of research, socio-economic phenomena of public life – a stage that ends with the summary and systematization of statistical data collected in the course of statistical observation and concentrated in the source numerical array for further quantitative analysis inseparably connected with the qualitative content of processes under study.

Russian scientists Agapova T.E., Suglobov A.E., Sidorova N.P. and Sharova N.M. [2, 3, 4] used statistical methods for cluster analysis; summary of these methods allowed to adapt them to assessing the financial security of the regions. The hierarchy and agglomeration of cluster analysis lead to the fact that the units of observation (they are municipal areas of the Moscow region in this scientific article) are combined into a number of subsets – clusters – based on the "closest neighbor" rule. At the same time, each cluster is formed as a kind of "cluster of units" or "constellation" of points close by "distance". The coordinates of points in a multidimensional (by the number of indicators) space is a measure of proximity. All numerical values are preliminarily standardized on a scale of $0 \le xij \le 1$ in order to reduce to a single coordinate dimension. This solved the problem of different numerical sizes of indicators for each municipal district and different units of measurement of each of the indicators. Standardization in this study will be carried out according to the method justified by Professor Dianov D.V. [5] based on the unit metrics: the maximum value of each indicator is taken equal to one ($x'maxj \rightarrow x''maxj = 1$), the minimum value is zeroed ($x'minj \rightarrow x''minj = 0$). Then the variation range for each indicator in the unit metrics will be equal to one: $R'' = x''maxj - x''minj = 1$. In turn, all the values of xij for each column of the working matrix are a difference of the initial numerical value and the minimum value of the indicator based on the source data as well. This will allow to preserve the general picture of the variation of indicators in the variation range, while other methods take the absolute zero for the origin, corresponding to the abscissa axis in the metrics of the source data. This is the transition from the table of the source data X with elements xij to the working matrix X' with elements x'ij. Further, the elements of the standardized matrix X'' will be obtained using the formula $x''ij = x'ij / x'maxj$. Now the array can be considered ready for clustering, i.e. the standardized maximum and minimum values of all indicators are equal to one and zero, respectively. The following transformation occurs: source data table → working matrix → standardized matrix, or: $X \rightarrow X' \rightarrow X''$. All standardized values are then summed line by line by a simple or weighted sum. The resulting column is processed according to a fairly well developed

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and very popular method based on the Sturges formula: N = 1 + 3,322*Lg(n), where the number of groups (clusters for a given column) depends on the number of observations ¬– the number of districts in the Moscow region.

After the formation of clusters that represent typologically homogeneous groups, the results of the obtained association are interpreted, and assumptions about the patterns of the object under study are suggested. Further, a regression method is used for each cluster to build models that quantify the effect of the explanatory factors (x1, x2,…, xm-1) on the result of the entire system operation – the resultant indicator (y).

The main trend of the phenomena development is represented by the same functions as in building the regression models: polynomials of different degree, exponentials, logistic curves, as well as other kinds of functions, where a0; a1; a2; … an are the parameters of the above polynomials, t is the designation of the time factor (sign factor). In the practice of statistical research, the parameters of polynomials with a low degree can have specific interpretation of the individual characteristics of the dynamics series. For instance, the parameter a0 in the linear function is treated as an estimate of the average conditions of a time series, while the parameter a1 (in other functions – a2, a3 as well) is treated as the characteristics of its acceleration. The choice of the equation and the most adequate model, as well as the estimation of its parameters are carried out on the basis of the method of least squares [6].

3. Statistical Analysis of the Regional Economy and Financial Security of the Moscow Region based pn Clustering

In this study, the method of multidimensional grouping – cluster analysis – is applied for clustering 36 municipal districts of the Moscow region, which are described by the following system of indicators:

1) Commissioning of residential buildings in the municipal territory – total area, thous. m2
2) Average headcount of employees in organizations, thous. people
3) Wage fund of all employees in organizations, mln rub.
4) Goods of own production shipped, own works and services performed (excluding small businesses), mln rub.
5) Retail trade turnover (excluding small businesses), mln rub.
6) Number of consumer service facilities for population, units
7) Volume of production of agricultural products (in actual prices), mln rub.
8) Number of unprofitable organizations, units
9) Financial result of profitable organizations, mln rub.
10) Average annual population, thous. people
11) Arrears in budget payments from the total amount of payable arrears, mln rub.

Agglomerative procedures of multidimensional grouping result in the formation of five clusters:

Cluster 1 – 11 districts: Lotoshinsky, Shakhovskoy, Serebryano-Prudsky, Taldomsky, Zaraisky, Ozersky, Kolomensky, Podolsky, Pavlovsky-Posadsky, Shatursky and Serpukhovsky municipal districts of the Moscow region.

Clusters 2 – 5 districts: Volokolamsky, Kashirsky, Mozhaysky, Lukhovitsky, Orekhovo-Zuevsky municipal districts of the Moscow region.

Cluster 3 – 7 districts: Yegoryevsky, Ruzsky, Klinsky, Voskresensky, Chekhovsky, Pushkinsky, Shchelkovsky municipal districts of the Moscow region.

Cluster 4 – 7 districts: Naro-Fominsky, Solnechnogorsky, Lubertsky, Istrinsky, Stupinsky, Noginsky, Dmitrovsky municipal districts of the Moscow region.

Cluster 5 – 6 districts: Sergievo-Posadsky, Ramensky, Leninsky, Krasnogorsky, Odintsovsky, Mytishchinsky municipal districts of the Moscow region.

Attention is drawn to the same vector direction of all explaining sign factors without exception along with the resultant indicator – arrears in budget payments. A minor remark is made only for the indicator describing the output of agricultural products: like all indicators, it shows a growth trend along with the indicator of arrears in budget payments, while there is a violation in the ranking of its average cluster values (cluster 3). Peculiarities of the cause-effect relationships should be considered by regression models within each cluster.

The first cluster covers the smallest territorial administrative units, where average population barely exceeds 40,000 people. This is also the lowest level of industrial output described by the shipment indicator, the average value of which is slightly more than 11 bln rub. in 2017 for this group.

At the same time, the municipalities of the first cluster are more likely to have an agricultural focus: there is a high value of the indicator of the shipment of agricultural products, with a large margin, – almost 45 mln rub. per 1 thous. residents, with one of the lowest values of industrial output – about 260 mln rub. Attention is also drawn to the lowest level of specific arrears in budget payments – as little as 3.02 mln rub. per 1 thous. people.

4. Factor Analysis of the Regional Economy and Financial Security Using Regression Models

A regression model that quantitatively describes the dependence of arrears in budget payments on the factors considered for the first cluster is provided below:

$$\hat{y}1 = - 45{,}003 - 0{,}042*x3 + 0{,}009*x4 + 0{,}01*x5 + 0{,}667*x6 – 0{,}01*x7 + 26{,}72*x8$$

The following entered the model with a positive sign:

Shipment of own produced goods. Its growth by 1 mln rub. predetermines the growth of the budget arrears indicator by 9 thous. rub. The situation is rather alarming in the districts of the first cluster, since it is most likely about the impossibility of fulfilling obligations to the budget due to the untimely settlements between buyers and suppliers. Such a situation was described as a non-payment crisis in the 90s. The increase in the shipment of goods by 1% is accompanied by an increase in the budget arrears by 0.77%.

Retail trade turnover. The same interpretation as for shipped products: symptoms of a non-payment crisis. However, when it comes to such a field as retail trade, the aspect related to the discipline for fulfilling tax obligations must also be taken into account, as it has always acted as a defector of economic development. Growth in the volume of retail trade by 1 mln rub. increases the budget arrears to a greater extent than the shipment of finished goods – by 10 thous. rub. The coefficient of elasticity indicates a change in the resultant indicator upward by 0.19% with the growth of retail trade by one percent;

Number of consumer service facilities for population. The situation typical for the consumer market is also observed here, when entrepreneurs are in no hurry to pay to the budget. This often happens for subjective reasons: due to the prioritization of spending funds received as income not in favor of meeting financial obligations to the state, primarily taxes and fees. The corresponding parameter of the regression model, b6=0,667, in-

dicates a significant impact of household organizations on the level of total budget arrears;

Number of unprofitable organizations. The army of these organizations, increasing for each of them, means a shortage of timely budget funds for 26.72 mln rub. This could actually doom the system of economic security of the Moscow region due to such a large numerical value. However, the economic catastrophe does not occur due to a very small number of such organizations in the districts of the first cluster – no more than 6 an average in the districts, as in the Moscow region in general.

The following factors have a reducing impact on budget arrears indicator in the first cluster:

Wage fund for employees in all organizations. This figure can be considered as an indicator of economic development. Its indicative idea is that organizations able to provide decent and timely payment to their employees will not be malicious debtors to the budget system. The growth of the wage fund by 1 mln rub. is accompanied by a decrease in budget arrear by 0.042 mln rub. or by 1.12%, with an increase in the payroll in organizations by 1%;

Volume of agricultural production. A huge range of measures aimed at supporting domestic agriculture, including taxation, creates both a favorable, very transparent background for the economic growth of this industry, and a precondition for a small level of obligations to the budget system, in comparison with other market producers. Especially given the fact that the first cluster was described as agrarian.

Similarly, regression models should also be considered for the remaining clusters obtained.

5. Conclusion

The study explored the possibility of applying mathematical statistical methods for conducting econometric and multidimensional analysis of the main indicators of the socio-economic development and economic security of the Russian region (Moscow region) for 2017. The study was carried out for municipalities – districts of the Moscow region. The application of the method of cluster analysis allowed to form homogeneous groups of districts that were described as either agrarian, or defense industrial, or close to megacities in urbanization, etc. A separate regression model was built for each cluster that reflected the specific features of the formation of one of the most significant indicators of the economic picture of the region – namely, the budget arrears. The main figures that determined its level (although quite differently in all clusters) were such indicators as payroll of all employees; shipment of own produced goods, number of unprofitable enterprises, and other factors.

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