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Changes in the Structure of Tax Revenues of Russian Regions

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ABSTRACT

The **purpose** of the study is to justify the use of the invariance property of the index method to study the change in the structure of tax revenues of Russian regions in the period from 2017 to 2021. The object of the study is eighty-five regions of the Russian Federation, and the subject is their financial and economic activities. Data from Rosstat and the Russian Federation's FTS were used for the analysis. To date, the index **method** is actively used in the conduct of economic analysis at the macro- and meso-levels. The **novelty** of the study is that only the authors of the article on the basis of indices monitor the state of activity of the regions of the country, based on their tax revenues. The quantitative analysis is implemented using the statistical processing and data visualization functions of the R programming language. The intersubjective comparison was done to identify areas that require financial and economic transformation to improve the activities of the country's regions. The comparison is made not only for one time, but also in dynamics. The **results** of the statistical analysis showed that the proposed tax income effectiveness index is an invariant indicator, independent of time and changes in the amount of tax income. It follows from the stationarity of the considered feature that the index values for 2017–2021 can be combined into a single homogeneous statistical aggregate. It was **concluded** that the index of effectiveness could be used as a grouping feature for the classification of Federation entities. The methodology developed can allow to intensify the socio-economic growth of the regions, indicating points requiring changes. In this regard, the results of the analysis can be useful to: the Ministry of Finance of the Russian Federation and the Federal Tax Service of the Russian Federation for the development of financial and tax policy; the Ministry of Economic Development and administrations of the subjects of the Russian Federation, indicating the economic zones of regions that need to be improved; to representatives of the business community when conducting economic analysis of regions.

Keywords: statistics; taxes; employed population; regional economy; public administration

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INTRODUCTION

Despite the fact that the Russian economy is currently in a difficult situation, there are still serious prerequisites for its sustainable economic growth. The imposed sanctions are encouraging Russian companies to develop their own production. Economic forces are mobilized through import substitution. In this regard, it is necessary to conduct a regular financial and economic analysis of the effectiveness of the activities of the regions of our country. These studies are expected to be able to identify growth points and areas of change.

In a field of knowledge such as management, the described direction of activity is called the "definition of the point of reference". One way to determine this point is to analyse the performance of competitors in order to improve their own activity. The authors of the article consider the regions of Russia as competing economic entities. A comparative assessment can identify areas that need improvement and indicate future developments. In order to compare the economic subjects of the Russian Federation, an index method was developed to assess the effectiveness of the functioning of the regions of our state [1, p. 82]. With the required tools for conducting inter-subject comparisons, including by economic industries, the authors of the paper conduct constant monitoring of the effectiveness of the activities of all subjects of the Russian Federation (note that there were 85 during the reporting period 2017–2021). Furthermore, improving the effectiveness of the operation of the lagging regions solves the problem of economic imbalance, as noted by the renowned economist G. B. Kleiner [2]. Addressing this aspect will reduce the level of interregional inequality that the authors of this article write about in the paper [3, p. 63].

METHODS

The purpose of the study is to analyse the change in the structure of tax revenues among the subjects of the Russian Federation in the period from 2017 to 2021. The subjects of this study are eighty-five subjects of the Russian Federation. The object is the financial and economic activities of the regions, measured by the amount of taxes and income collected in their territories.

Let us answer the question: why are these subjects and this particular period of time chosen? In order to calculate the change in the structure of tax revenues received from the constituent subjects of the Russian Federation, it is necessary to have a permanent structure of economic subjects and types of economic activity that create tax income. Note that our country's number of regions varies from time to time. The most recent transformation occurred in 2022, when four new subjects, including the Donetsk People's Republic, joined the Russian Federation.[1] Previous changes in the number and structure of the subjects of the Russian Federation occurred in 2014 and were caused by the return of the Republic of Crimea and Sevastopol to Russia.[2]

The upper time limit of surveys has been reduced due to the fact that the authors in the analysis used data on the number of employed populations provided by Rosstat. This information is openly available for a period of two years. Thus, the upper time limit corresponds to 2021. We have data on the number of employed population (EP) and tax income (TI) by type of economic activity since 2006. But here we need to consider another reason for the temporary restrictions. In our country, all economic sectors are distributed

[1] Federal Constitutional Law from 4 October 2022 No. 5 "On the admission of the Donetsk People's Republic into the Russian Federation and the formation of a new entity in the Russian federation — the Donetsk People's Republic". Garant URL: https://www.garant.ru/products/ipo/prime/doc/405281303/ (accessed on 04.03.2023).

[2] Federal Constitutional Law from 21 March 2014 No. 6 "On the admission to the Russian Federation of the Republic of Crimea and the formation of new subjects in the Russian Federation — the Republic of Crimea and the city of federal significance of Sevastopol" (with amendments and additions). Garant. URL: https://constitution.garant.ru/act/federative/70618342/ (accessed on 04.03.2023).

by type of economic activity, which is introduced and modified according to the All-Russian Classification of Economic Activities (RCEA).[3]

Considering the information being analyzed (number of EPs and tax revenues by type of economic activity), it should be noted that the last significant change in the data structure for our research was in 2017. For example, from the type of economic activity "Transport and Communications" two separate areas have been formed: "Transports and Storage" and "Information and Communication Activities". The lower time limit therefore corresponds to this year. Therefore, the change in tax revenues will be considered in the period from 2017 to 2021 in 85 subjects of the Russian Federation. It can be seen that the choice of the number of regions and the period of time was influenced by reasons of a state-political, economic and technological nature. Considering the detailing of economic industries by type of economic activity, one can note another fact. The Federal Tax Service of the Russian Federation gives a deeper sectoral divide, and the research is limited to aggregated data provided by Rosstat.

The answer to the third question follows. Why this data?

The paper [3, p. 63] considered the financial and economic activities of any of the subjects of the Russian Federation as a conceptual model of operating financial flows consisting of tax and non-tax revenues, customs payments and insurance contributions. These payments are distributed between budgets at different levels and are also paid to extrabudgetary funds. The result of the activity of such an economic system are tax revenues to the revenue part of the consolidated budget of the subject of the federation and the federal budget from the activities of companies located within the borders of the region. In turn, the system's inputs are payments from the federal budget, such as: grants, subventions, transfers and subsidies. Some of the financial flows listed are feedback elements.

Let us make an analogy between the functioning of the Russian Federation and the activity of a commercial organization. One of the main objectives of an organization in a market economy is to generate profit, which is a measure of the effectiveness of its activities. For the convenience of comparing companies among themselves, we can divide this profit into the assets that form it. One of the profit-generating resources is the company's staff. Therefore, in order to compare the performance of the company with that of its competitors, it is necessary to divide the amount of profit received by the number of staff it generates.

In our case, one of the main indicators determining the profitability of the Russian Federation is the tax revenues collected in its territory. For a more accurate comparison of regions, divide the tax revenues of each region by the number of people employed in their creation. As mentioned above, information on tax revenues is provided by the Federal Tax Service of the Russian Federation, and data on the employed population — Rosstat. Note, that this information is freely distributed and can be used in economic research.

The article makes a comparative financial and economic assessment of the state of the Russian Federation's subjects using the index method. This area of research falls under statistical methods, and its applied component is used in a variety of scientific and technological sectors. Most often, the index method is used in conducting economic research. This examines the various aspects of economic, financial and managerial activities.

The index method is widely used in macroeconomics. Today, the Inclusive Development Index (IDI) is an alternative measure to the GDP indicator. The IDI more accurately defines the socio-economic status

[3] Russian Standard "OK 029–2014 (KDES Ed. 2). All-Russian Classification of Economic Activities" from 31.01.2014 No. 14. Collection of legislation of the Russian Federation with amendments and additions in ed. from 11.05.2023.

of countries in the world, taking into account the level and rate of improvement of overall socio- economic progress. The indicator is based on twelve indicators, which are combined into three groups [4, p. 1117; 5, p. 779]. One of the indicators used in IDI is the Human Development Index. Numerous works by foreign [6, p. 425; 7, p. 443] and Russian authors [8, p. 54; 9, p. 75] are devoted to the analysis of this indicator. Russian scientists also use this index to assess the development of human capital in our country [10, p. 122; 11, p. 44].

Note that the index of efficiency of functioning of the subjects of the Russian Federation, developed by the authors of the article, is also inclusive and is based on fourteen indicators, corresponding to fourteen types of economic activity [1, p. 82]. For comparison and development of regions of our country, IDI is considered in papers [12, p. 611; 13, p. 1]. Indices are also actively used to analyze inequalities in the distribution of income, services [14], regional tax revenues [3, p. 63] and etc. The use of indices for assessing income distribution inequalities is discussed in the paper [15, p. 1199; 16]. This aspect of research is also considered in the papers of Russian economists [17, p. 72; 18, p. 5].

The index method has been widely used in various fields of science and technology. On the basis of indices, analysis of the impact of ecology on the quality of life of the population [19, p. 4; 20] and assessment of climate risks [21]. This method can also be used to compare and evaluate the quality of services provided [22, 23]. Indices are also used to assess the change in consumer prices, characterizing the average rate of change in commodity prices over a given period [24, p. 69; 25, p. 368]. Indices are actively used in statistics, for example, in confirmatory factor analysis (CFA) [26, p. 455; 27, p. 1], and in econometric studies for modeling economic processes [28, p. 113; 29, p. 168]. Indices can also be used to compare economic sectors with each other [30]. Note that the authors developed an index method of analysis of the effectiveness of the functioning of the subjects of the Russian Federation, which allows comparing not only these subjects but also the economic systems of the same level of scientists.

In the paper [1, p. 82] was proposed a relative indicator of the effectiveness of the activities of the subjects of the Russian Federation, which is separate from the division of the amount of tax revenues to the average annual number of the employed population of the subject of the Russian Federation by a certain type of economic activity. It was called the relative performance of tax revenues (RPTR) by type of economic activity. For any region of the country, fourteen such indicators can be determined (based on the number of types of economic activity, m = 14) — $RPTR_{ij}$. In this case, index *i* takes values from 1 to 85, and index *j* corresponds to the type of economic activity and is located between 1 and 14. The $RPTR_{ij}$ indicator reflects the average tax income per region that one employee engaged in the respective type of economic activity brings to the country budget. Further $RPTR_{ij}$ will be designated as $X_{i, j}$.

We calculate for each type of economic activity the average value of $RPTR_{ij}$ for all subjects of the Russian Federation. As a result, we get thirteen mean values, which were determined by the simple average formula:

$$\bar{X}_j = \frac{\sum_{i=1}^{n} X_{ij}}{n}.$$

For each tax we determine the dispersion D_j and average square deviation σ_j of the relative indicator of tax income effectiveness for all subjects. These variation indicators were calculated using the following formula:

$$D_j = \frac{\sum_{i=1}^{n} (X_{ij} - \bar{X}_j)^2}{n-1} \text{ and } \sigma_j = \sqrt{D_j}.$$

Using calculated mean values, we will center all relative X_{ij} indicators according to the following

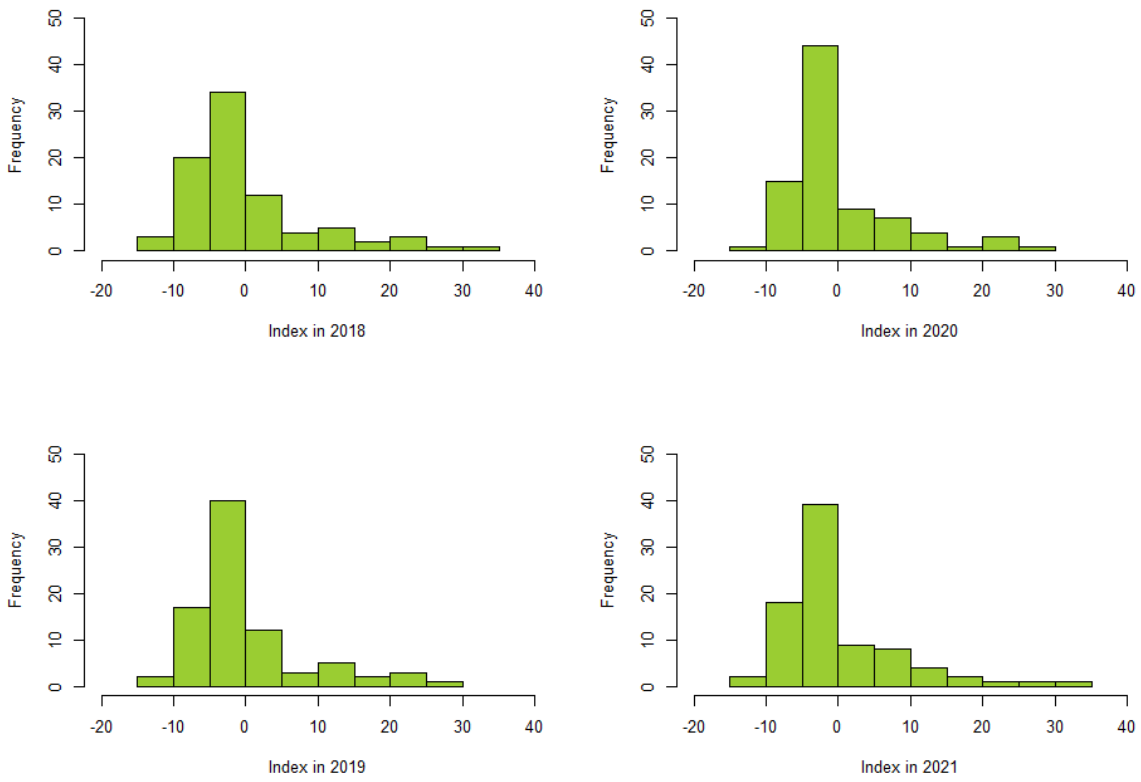

Fig. 1. **Distribution of the Tax Revenues Efficiency Index of the Russian Regions**

Source: Calculations of the authors according to the data of the Federal Tax Service of the Russian Federation and Rosstat. URL: https://www.nalog.gov.ru/rn77/related_activities/statistics_and_analytics/forms/; https://rosstat.gov.ru/folder/210/document/13204 (accessed on 04.03.2023).

formula: $\dot{X}_{ij} = X_{ij} - \bar{X}_j$. If the calculated centralized relative indicators $\dot{X}_{ij}$ are normalized by means of average square deviation σ_j, then we get standardized relative performance indicators of tax revenues (indicators) for each type of economic activity for all subjects

$$U_{ij} = \frac{\dot{X}_{ij}}{\sigma_j}.$$

Note that U_{ij} values have no dimensions. Furthermore, all mean values of the standardized relative performance of tax revenues for each type of economic activity are zero, i.e. $\bar{U}_j = 0$ for all j, and all differences of these indicators

$$D_j = \frac{\sum_{i=1}^{n}(U_{ij} - \bar{U}_j)^2}{n-1}$$ are equal to one unit.

Since various external and internal environmental factors influence the scope of taxation of the fourteen types of economic activity, it can be assumed that the standardized U_{ij} values are subject to different laws of distribution, but with the same averages and dispersions. Thus, any region of Russia is characterized by a system of non-dimensional indicators with the same mean values equal to zero, and dispersions equal a unit.

If for each subject to summarize the indicators obtained for all types of economic activity, then in the end we will have the values of some aggregate indicator, reflecting the effectiveness of tax revenues in the entity for all types of economic activities:

$$I_i = \sum_{j=1}^{m} U_{ij}.$$

The resulting index of tax revenue effectiveness is based on 13 indicators, each of

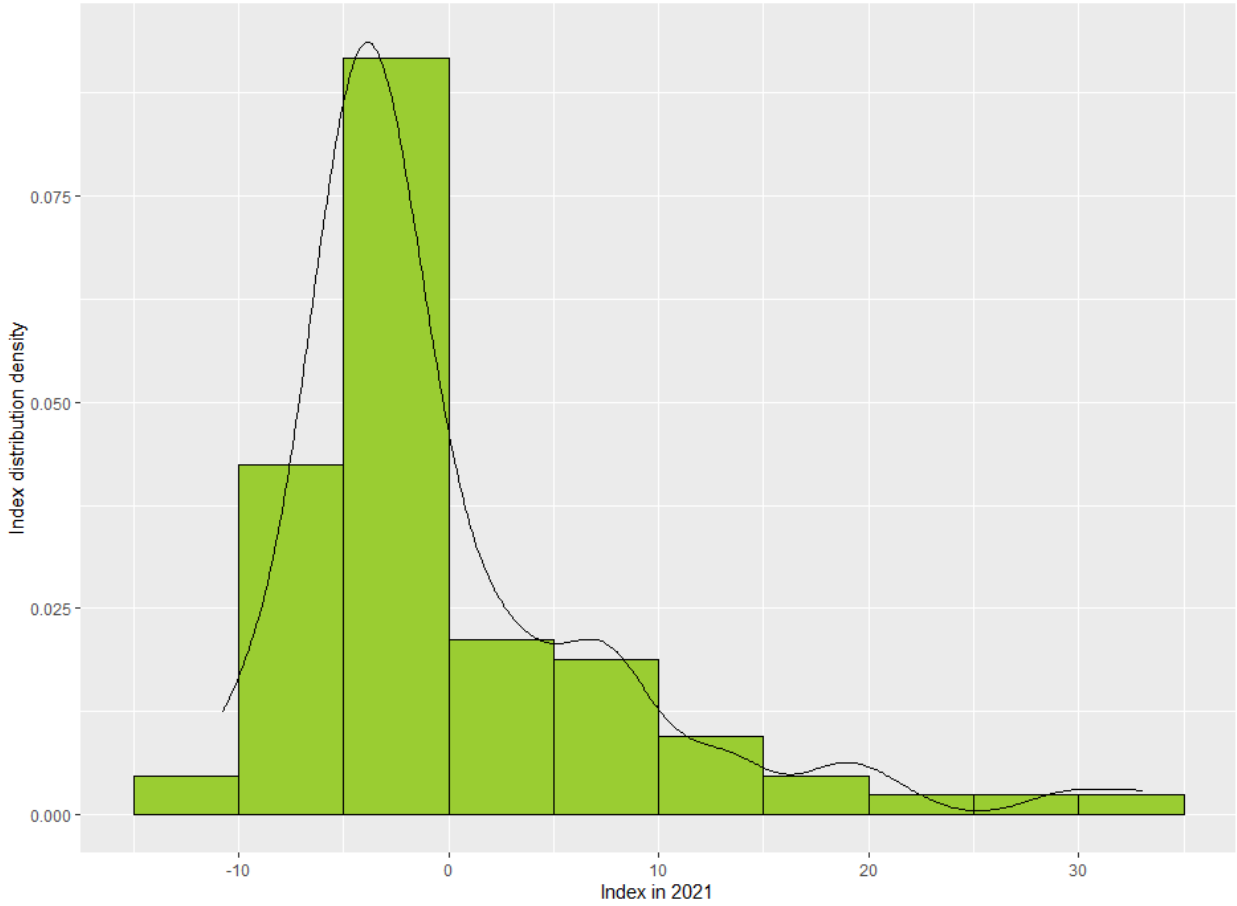

Fig. 2. **Kernel Density Estimation of the Index Calculated from the Data on Tax Revenues of the Russian Federation's Subjects in 2021**

Source: Calculations of the authors according to the data of the Federal Tax Service of the Russian Federation and Rosstat. URL: https://www.nalog.gov.ru/rn77/related_activities/statistics_and_analytics/forms/; https://rosstat.gov.ru/folder/210/document/13204 (accessed on 04.03.2023).

which corresponds to the type of economic activity and assesses the level of economic development of the subject (the value of the index *i* is equal to I_i).

RESULTS

We combine the collected data on the tax revenues of the constituent subjects of the Russian Federation, the number of their employed population by types of economic activity for the period 2017–2021 into one data set and use the tools of statistical processing and visualization of the R-language. Since, according to the authors' idea, the tax income effectiveness index is intended to compare subjects among themselves, the question arises: does this indicator depend on time or can it be considered an invariant measure of the efficiency of tax revenues of Russian entities in the period considered? If this indicator does not depend on time (at least, in the period considered 2017–2021), it can be used as some grouping factor for the subjects of the Russian Federation in terms of the effectiveness of their tax revenues.

We answer on these questions by using some methods of data processing and visualization. *Fig. 1* shows the histograms of the distribution of the index in different years of the period under consideration.

Comparing the graphs (*Fig. 1*), it can be noted that the distribution of the index in different years is similar in appearance, has a pronounced right asymmetry and are is

Table 1

Results of Checking the Normality of the Index According to Data for 2021

Statistical tests	Verification results
Shapiro-Wilk normality test	data: idfs$y2021 W = 0.81507, p-value = 6.119e – 09
Lilliefors (Kolmogorov-Smirnov) normality test	data: idfs$y2021 D = 0.21377, p-value = 2.458e – 10

Source: Author's calculations.

Table 2

Results of Checking the Normality of the Index According to Data for 2017–2021

Statistical tests	p-value				
	2017	2018	2019	2020	2021
Shapiro-Wilk normality test, p-value	2.12e – 08	1.05e – 08	5.79e – 09	2.45e – 09	6.12e – 09
Lilliefors (Kolmogorov-Smirnov) normality test, p-value	1.03e – 08	1.2e – 09	4.23e – 09	1.46e – 10	2.46e – 10

Source: Author's calculations.

not similar to the normal distribution. For example, *Fig.2* presents a kernel density estimation of the index distribution density for 2021. It is apparent that this estimate is very different from the normal distribution curve.

Several special statistical tests are available to verify the hypothesis of the normal distribution. Using the R-programming language, almost all of these tests can be implemented either as basic functions or functions that are part of individual packages. We will use one basic function shapiro.test(), implementing the Shapiro-Wilk test, and the lillie.test() function from the nortest package, with which you can perform the Kolmogorov-Smirnov test in the Liliefors modification. *Table 1* shows the results of these tests for tax revenue data in 2021 (the Shapiro-Wilk and Kolmogorov-Smirnov tests in the Liliefors modification, respectively).

It is apparent that the combined values of p-value in both tests are small, much less than the values used in practice of the significance level of 0.001–0.1. This suggests that the zero hypothesis of the normal law of index distribution should be rejected. Similar estimates were made for other years of the period under review (*Table 2*). Everywhere the hypothesis of normal law is rejected.

Based on the results given in *Table 2*, it can be concluded that the law of distribution of the index in the period 2017–2021 is different from the normal law.

One of the important conditions for the applicability of the dispersion analysis is the homogeneity (homoscedasticity) of the group (year) dispersions of the attribute being studied. To test the homoscedasticity of the dispersions in our case we use the Levene test. We use the leveneTest function from the car package of the R-programming language. The results of this function are shown in *Table 3*.

The resulting p-value of 0.9715 is much greater than the practical values of the significance level of 0.001–0.1. Therefore,

Table 3

Results of Using R-Language Functions in Data Analysis of 2017–2021

Statistical tests	Verification results
Levene's Test for Homogeneity of Variance (center = median)	Df F value Pr (>F) 4 0.1297 0.9715
Kruskal-Wallis rank sum test	data: idf$index by idf$year Kruskal-Wallis chi-squared = 0.35702, df = 4, p-value = 0.9858

Source: Author's calculations.

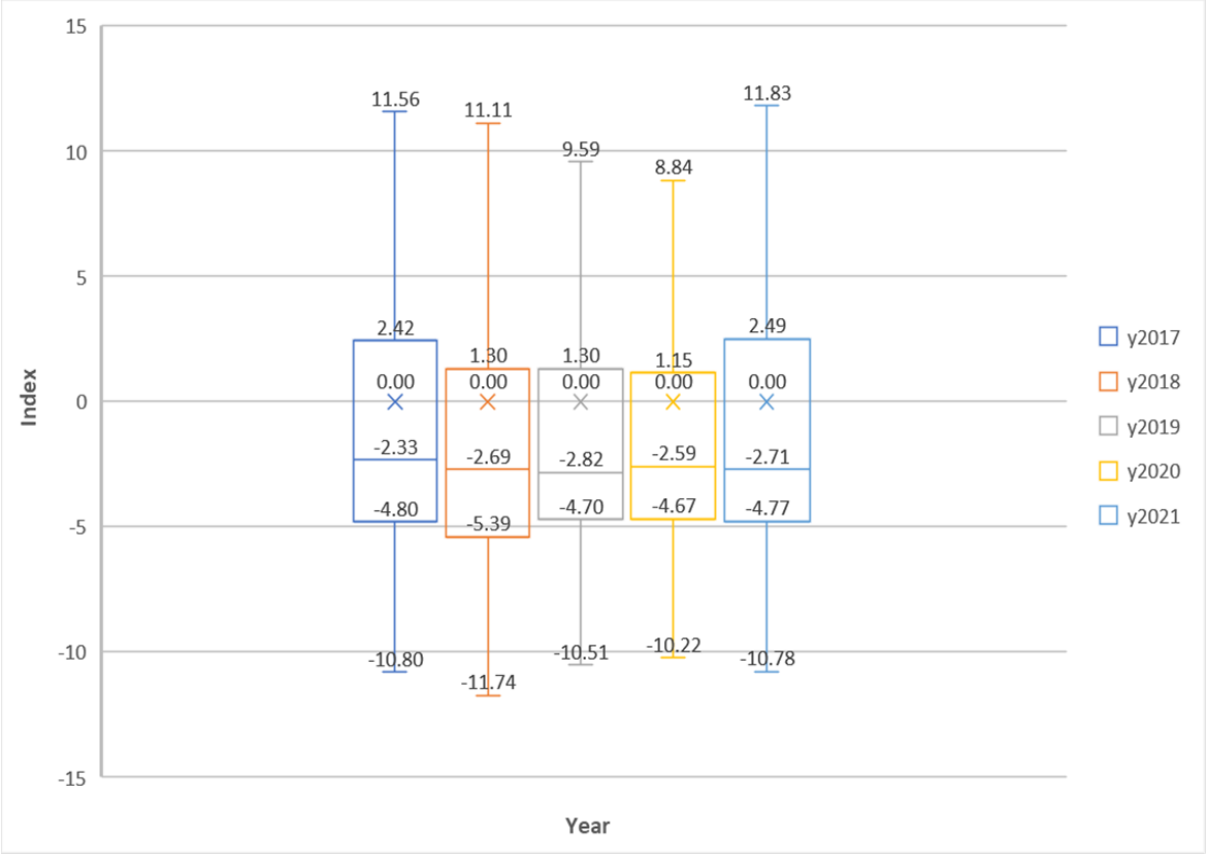

Fig. 3. **Charts of the Scope of the Tax Revenue Index in 2017–2021**

Source: Author's calculations.

the zero hypothesis of equality of group (year) dispersions is not rejected. Thus, the condition of uniformity of the dispersions in our case is fulfilled.

It is known that the basic requirements for the use of classical one-factor dispersion analysis are the condition of the normal distribution of the studied feature and the homogeneity (homoscedasticity) of the dispersions in all comparable groups. In our case, there is a deviation of the distribution of the index from the normal law and observance of the condition of uniformity of the dispersions. At the same time, the

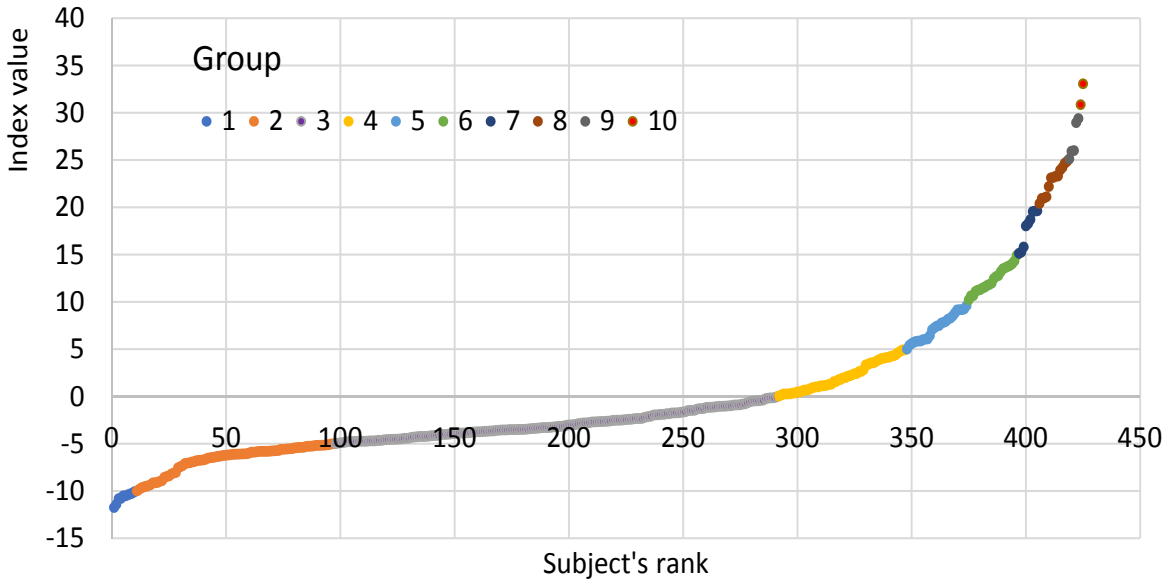

Fig. 4. **Distribution of the Russian Federation Subject's by Index Value in 2017–2021**

Source: Author's calculations.

form of the distribution of the index in all the comparable groups is similar (*Fig. 1*). Therefore, we will use the Kruskal-Wallis criterion for dispersion analysis. This method can be attributed to nonparametric analogues of one-factor dispersion analysis. It is usually used when the assumption of the normal law of distribution of the attribute being studied is violated. In the R programming language, the Kruskal-Wallis dispersion analysis is performed using the basic kruskal.test function(). The results of the Kruskal-Wallis dispersion analysis are presented in *Table 3*. The comparison of the p-value 0.9858 with the level of significance from the range 0.001–0.1 allows the adoption of a zero hypothesis about the equality of the mean values (median) of the index in different groups (years).

The easiest way to evaluate the uniformity of the dispersion and equality of the mean values of the attribute being studied is to visualize its variation using a scale chart (*Fig. 3*). It is evident that the visualization of comparing the values of the index in different years allows to confirm the correctness of the findings of the tests performed. Thus, the values of the tax income effectiveness index, calculated for each year of the period 2017–2021, can be considered as a single uniform statistical set. Therefore, there are all grounds to assume that the structure of tax revenues of the subjects of the Russian Federation during 2017–2021 has not changed.

Based on the fact that the indicator is stationary (not dependent on the time, at least in the period considered), it can be used as some grouping factor for the subjects of the Russian Federation in terms of the effectiveness of their tax revenues. For example, *Fig. 4* shows the distribution curve of the Russian Federation by the size of the index (ranked in order of index growth) segmented into groups (classes). As an example, ten groups are considered.

From *Fig. 4,* it follows that the distribution curve of the subjects of the Russian Federation by the size of the index (ranked in order of index growth) is a seemingly smooth, monotonous, increasing nonlinear function. At the same time, the values of the indices

of the subjects, divided into groups, are well "settled" on the general curve.

CONCLUSION

It can be concluded that the work analysed the effectiveness of the activities of eighty-five subjects in the Russian Federation. The index method developed by the authors of the article was applied to investigate the effectiveness of the activities of the regions. In order to identify zones in the activities of the regions in need of transformation, an inter-subject comparison was carried out not only in one temporary period, but also in the dynamics of five years. The study takes the maximum possible time period — from 2017 to 2021. The temporary limitations are related to changes in the number of subjects of the Russian Federation and the structure of the data used. For analysis, data on tax revenues and the number of employed persons provided by the Federal Tax Service of the Russian Federation and Rosstat, respectively, were used. R-programming language used for data processing and calculation visualization.

The results of the statistical analysis presented in the paper allow us to say that the tax income effectiveness index is indeed an invariant indicator of tax income. Its value does not depend on the amount of income itself or the time in which it was received (at least within the time frame under consideration). It follows that during 2017–2021 there were no significant changes in the structure of tax revenues of the subjects of the Russian Federation by type of economic activity. Since the feature under consideration is a stationary value, the values of the index obtained in 2017–2021 can be combined into a single homogeneous statistical set. This allows us to use the performance index as a grouping feature for classifying subjects of the Russian Federation.

It should be noted that the subjects of the Russian Federation have all the advantages for their economic growth. In the opinion of the authors, the proposed index method can be used in the development of new approaches and flexible instruments of financial and tax policy, targeted at individual groups of subjects of the Russian Federation, which have the prerequisites for the expansion and improvement of certain types of economic activity in their territory.

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