Fiscal Policy Effectiveness Assessment Based on Cluster Analysis of Regions

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Abstract
The efficiency of the regional fiscal policy implementation is based on the achievement of target criteria in the formation and distribution of own financial resources of local budgets, reducing their deficit and reducing dependence on transfers. It is also relevant to compare the development of financial autonomy of regions in the course of decentralisation of fiscal relations. The study consists in the cluster analysis of the effectiveness of fiscal policy implementation in the context of 24 regions and the capital city of Kyiv (except for temporarily occupied territories) under conditions of fiscal decentralisation. Clustering of the regions of Ukraine by 18 indicators of fiscal policy implementation efficiency was carried out using Ward's minimum variance method and k-means clustering algorithm. As a result, the regions of Ukraine are grouped into 5 homogeneous clusters. For each cluster measures were developed to increase own revenues and minimize dependence on official transfers to increase the level of financial autonomy of the regions. It has been proved that clustering algorithms are an effective tool in assessing the effectiveness of fiscal policy implementation at the regional level and stimulating further expansion of financial decentralisation of regions.

Keywords:
Indicator, Region, Ukraine, Model, Decentralization, Cluster, Component, Ward's minimum variance method, k-means clustering algorithm.

1. Introduction

The problem of assessing the effectiveness of implementation of fiscal policy at the regional level has its own specifics. Its comprehensive solution is impossible without taking into account the heterogeneity of development of all regions within the same country, based on territorial and demographic characteristics, the formation of production, social and financial results, etc. There is also a need to monitor the state of formation of sources of financial resources of local budgets, their targeted use, covering the budget deficit, dependence on inter-budgetary transfers, etc., as well as to conduct a comparative analysis and ranking of regions based on the values and criteria of indicators that reflect different aspects of fiscal policy implementation. It is the monitoring results that provide information as to which regions implement fiscal policy more or less effectively. Another aspect of assessment is to take into account the similarity of the development results of individual regions in the course of the implementation of fiscal policy. The application of cluster analysis helps identify such circumstances, especially when the sample size is more than 20 objects and they differ significantly in their financial and economic characteristics.

The process of implementation of the state fiscal policy at the regional level is implemented comprehensively in three main directions: revenue, expenditure and inter-budgetary [1]. At the same time, when conducting research on the example of Ukrainian regions, it is necessary to take into account the implementation of the financial decentralisation reform, which began in 2014. When forming indicators of the state of implementation of fiscal policy at the regional level, the main efficiency criterion is the expansion of financial autonomy of administrative-territorial units in the formation and disposal of financial resources, as well as reducing dependence on official transfers during the implementation of the decentralization reform. In addition, the evaluation of the effectiveness of fiscal policy implementation takes into account both the heterogeneity of regional economic development and the possibility of grouping individual regions due to the similarity of fiscal results.

2. Theoretical Consideration

Among the recent studies devoted to the assessment of fiscal relations, one should highlight the works devoted to methodological and applied problems of assessing fiscal policy by traditional methods of statistical data processing to form indicators of regional fiscal policy implementation efficiency. To increase the reliability of the cluster analysis,

Manuscript received July 5, 2022
Manuscript revised July 20, 2022
https://doi.org/10.22937/IJCSNS.2022.22.7.10

it is also necessary to take into account the studies that use clustering algorithms in the comparative analysis of different countries or regions by indicators of fiscal policy.

To form the optimal number of indicators of fiscal policy effectiveness and their feasibility, one should take into account the findings of many scientists, in particular I. Luk'ianenko, and M. Sydorovych [2] in terms of assessing the relationship between budgetary and macroeconomic indicators, as well as proposals on directions for reforming the budgetary and tax systems of Ukraine. The findings that the level of public debt and trade openness have a significant impact on fiscal efficiency by reducing the size of fiscal effects in Croatia, Slovenia and Serbia are important [3]. Equally important is the study of the impact of fiscal policy on economic growth, taking into account the differences in institutions and levels of external debt [4] and the impact of fiscal rules on the budget [5]. One should take into account the reassessment of the basic provisions of optimal fiscal policy [6]; the results of assessing the impact of the level of financial decentralization on the indicators of socio-economic development of territories and the gap between the growth rate of revenue and expenditure powers of budgets at different levels and the GDP growth rate in developed countries [7]; the role of fiscal strategy in ensuring macroeconomic stability and accelerating economic growth in developed and transformational economies [8]; the positive impact of Iran's fiscal policy components on reducing inequality and poverty and the effectiveness of inter-budgetary transfers and subsidies [9]. The results of an empirical assessment of the effectiveness of fiscal policy in the context of the economic downturn in Azerbaijan caused by the COVID-19 pandemic obtained by S. Guliyeva et al. [10], who also proved the optimal structure of state budget expenditures. Obviously, the results of these studies will allow us to form indicators of the effectiveness of fiscal policy implementation at the regional level.

The experience of applying cluster analysis to study the effectiveness of fiscal policy implementation is revealed in the article by K. Konstantakis, T. Papageorgiou, P. Michaelides, and E. Tsionas [11], in which they prove, based on clustering of EU member states, that the most important countercyclical instruments of fiscal policy during 1996–2013 were social payments, social transfers and gross debt, while taxation had a destabilising character. This was also confirmed by the results of A. Szymanska [12] on 2009–2016 data, which also proved that countries with lower levels of public debt and budget deficits had a better fiscal system. D. Pirvu, A. Dutu, and C. Enachescu [13] proposed the use of clustering algorithms to rank EU member states based on their fiscal behaviour in terms of public expenditure and revenue, thus identifying groups of countries with public finance sustainability problems. I. Chuy, V. Kutsyk, and T. Andreikiv [14], D. Jakub, and E. Suchý [15] applied clustering algorithms to identify the types of financial systems of OECD member countries by indicators of centralisation and redistribution of GDP through the budget system, tax burden, debt burden, cyclically adjusted primary balance. The mentioned scientific papers substantiate the importance of using clustering algorithms for ranking countries in the context of fiscal policy implementation, which allows improving the quality of cluster analysis of Ukrainian regions by indicators of fiscal policy implementation efficiency.

The purpose of the article is to improve the methodological support for assessing the effectiveness of fiscal policy implementation at the regional level through the introduction of cluster analysis, and to develop directions for increasing the level of financial autonomy of regions, depending on their cluster affiliation.

At the preliminary stage of assessing the effectiveness of implementation of fiscal policy at the regional level, the basic indicators, according to which the clustering of regions will be implemented, are formed. It should be noted that such indicators are extremely relative, but they should be calculated taking into account the specifics of socio-economic development of administrative-territorial units and the specifics of local government reform on the basis of fiscal decentralization [16]–[21].

Therefore, in order to assess the effectiveness of fiscal policy implementation at the level of administrative-territorial units, indicators systematised according to the following features are taken: the state of the revenue component of fiscal policy in view of its decentralisation; the state of the expenditure component of fiscal policy in conditions of its decentralisation; the state of inter-budget relations; the effectiveness of regional development [22]–[24].

The classification of relative performance indicators of fiscal policy implementation at the level of administrative-territorial units is erected in Figure 1.

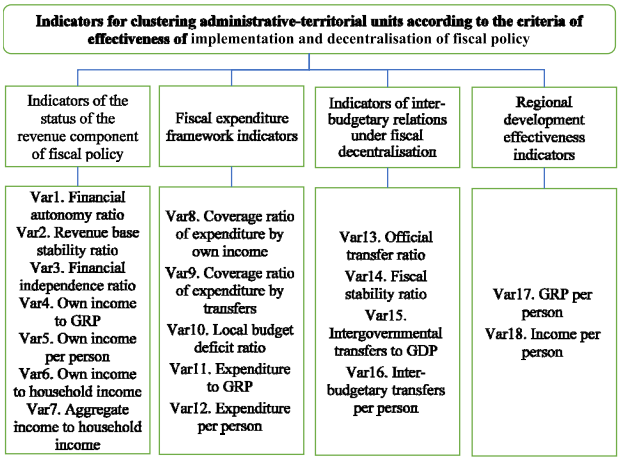

Fig. 1 Indicators of effective implementation and decentralisation of fiscal policy of administrative-territorial units

Source: *Authors' elaboration.*

Figure 1 shows 18 relative indicators underlying the algorithms for clustering administrative-territorial units according to the criteria of effectiveness of implementation and decentralisation of fiscal policy. The procedure for calculating the proposed indicators is as follows:

(i) indicators of the effectiveness of the revenue component of fiscal policy, taking into account its decentralisation:

Var1 is the ratio of own revenues of the consolidated regional budget (without transfers) to total revenues of the consolidated regional budget (including transfers);

Var2 is the ratio of revenues to the expenditures of the consolidated regional budget;

Var3 is the ratio of own revenues of the consolidated regional budget (without transfers) to inter-budget transfers;

Var4 is the ratio of own revenues of the consolidated regional budget (without transfers) to GRP;

Var5 is the ratio of own revenues of the consolidated regional budget (without transfers) to the number of available population of the region;

Var6 is the ratio of own revenues of the consolidated regional budget (without transfers) to the income of the region population;

Var7 is the ratio of revenues of the consolidated regional budget (including transfers) to the revenues of the population of the region;

(ii) indicators of efficiency of the expenditure component of fiscal policy in the context of its decentralisation:

Var8 is the ratio of own revenues (without transfers) to the expenditures of the consolidated regional budget;

Var9 is the ratio of the volume of official transfers to the expenditures of the consolidated regional budget;

Var10 is the ratio of deficit (surplus) to the total amount of revenues (including transfers) of the consolidated regional budget;

Var11 is the ratio of the consolidated regional budget expenditures to GRP;

Var12 is the ratio of the amount of expenditures of the consolidated regional budget to the available population of the region;

(iii) indicators of the effectiveness of inter-budget relations:

Var13 is the ratio of inter-budget transfers to revenues of the consolidated regional budget (including transfers);

Var14 is the ratio of inter-budget transfers to own revenues of the consolidated regional budget (without transfers);

Var15 is the ratio of official transfers to GRP;

Var16 is the ratio of official transfers to the existing population of the region;

(iv) indicators of regional development effectiveness:

Var17 is the ratio of the annual volume of GRP at actual prices to the size of the available population;

Var18 is the ratio of the annual volume of the population's income to the number of the available population of the region.

The second direction of the study consists in the application of clustering algorithms in assessing the effectiveness of fiscal policy implementation at the regional level. The clustering is based on the grouping of a plurality of 25 administrative-territorial units of Ukraine into subsets (clusters), so that the objects of each of the constructed clusters were the most similar to each other, compared to the objects of other clusters, by criteria of effectiveness of implementation of regional fiscal policy and decentralization. Such clustering algorithms as Ward's minimum variance method (Figure 2) and k-means clustering algorithm (Figure 3) were used.

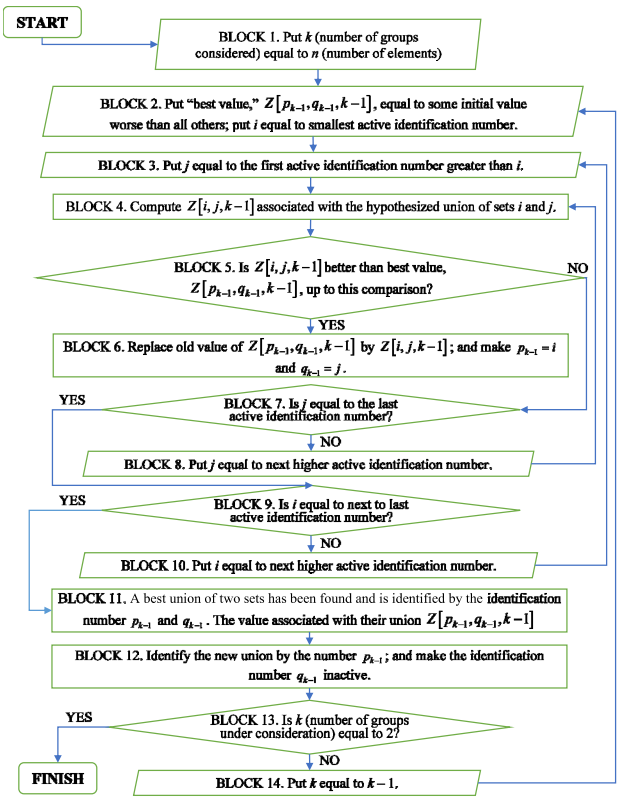

Fig. 2 Algorithm of Ward's minimum variance method

Source: *Improved for [25]–[26].*

Clustering of Ukraine's regions by indicators of fiscal policy implementation efficiency is carried out in order to monitor the results of the 2014 fiscal decentralisation reform and to develop ways to increase the level of financial autonomy of regional budgets.

The next stage of the cluster analysis is standardisation of indicators of effectiveness of regional fiscal policy implementation according to the formula:

$$x_i' = \frac{x_i - \overline{X}}{\sigma_x}, \quad (1)$$

where x_i' is the standardised value of the indicator x_i;

$\overline{X}$ is the average value of the indicator x_i;

σ_x – is the standard deviation of the indicator x_i.

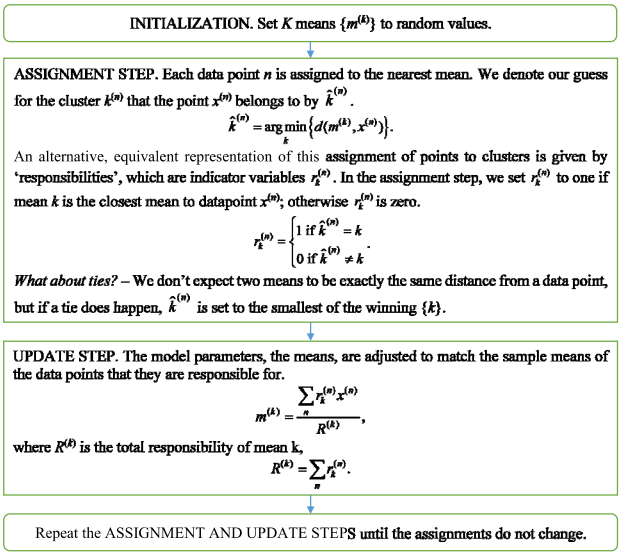

Fig. 3 k-means clustering algorithm

Source: *Improved for [27].*

3. Experimental Consideration

The annual averages for 2015–2019, which are shown in Figure 1, are summarised in Appendix A. The data in Appendix A shows that the budget of the Ukrainian capital Kyiv can be considered the most financially independent, as its revenues amounted to 71.5 % of total revenues, and the consolidated regional budget of Ternopil region is the most financially dependent, as its own revenues amounted to only 28.3 % of total revenues From the average annual values (for 2015–2019) of the revenue base stability ratio, we see that revenues of all regional budgets fully covered the costs – from 100.5 % (Zaporizhzhia region) to 105.4 % (Donetsk region). Kyiv's budget is also the most financially independent, as its own revenues (excluding official transfers) are 2.5 times the amount of inter-budgetary transfers, and the consolidated regional budget of the Ternopil region is the most financially dependent, with only 39.4 % of its own revenues covering inter-budgetary transfers. The ratio of personal budget revenues (excluding official transfers) to GRP ranged from 5 % (Kyiv) to 10.3 % (Chernivtsi region), to the population size – from 1.3 thousand UAH/person (Luhansk region) to 9.8 thousand UAH/person (Kyiv), to the population income – from 6 % (Luhansk region) to 10 % (Kyiv region). And the ratio of total budget revenues (including official transfers) to the population's income was lowest in Kiev (11 %) and highest in Volyn (24 %).

Kyiv's budget had UAH 0.74 for every hryvnia of expenditure. The budget of Ternopil region was the most dependent on transfers from the state budget, with 0.73 UAH of official transfers for every hryvnia of expenditure, and the budget of the capital city was less dependent on transfers from the state budget, with only 0.30 UAH of inter-budgetary transfers for every 1 hryvnia of expenditure. It is also worth noting the surplus of all the studied budgets according to the annual average data for 2015–2019. The budgets of Kyiv and Luhansk regions were the most surplus, with revenues exceeding expenditures by 4 %, and the consolidated budget of Zaporizhzhia region was the least surplus, with a 0.5 % surplus of revenues over expenditures. The ratio of budget expenditures to GRP ranged from 6.6 % (Kyiv capital city) to 33.8 % (Chernivtsi region), and the ratio of expenditures to population ranged from 3.2 thousand UAH/person (Luhansk region) to 13.2 thousand UAH/person (Kyiv capital city).

The budget of Kyiv capital city was the least dependent on transfers from the state budget. Thus, the share of inter-budgetary transfers in the revenues of the capital's budget was the lowest compared to the rest, amounting to only 28.5 % (40 % of own revenues), while in the revenues of the consolidated budget of Ternopil region, the share of inter-budgetary transfers reached 71.7 %, and 2.5 times the amount of inter-budgetary transfers exceeded the volume of own budget revenues (not including transfers) – this is the worst result. Also, the ratio of inter-budgetary transfers to GRP was the best for Kyiv, at only 0.2, and the worst for the consolidated budget of Chernivtsi region. Per person, the least amount of inter-budgetary transfers – 2 thousand UAH/person – was in Luhansk region, and the most – 6.9 thousand UAH – in Rivne region.

One can also observe considerable disproportions in the GRP production – the highest GRP volume per capita is 198.6 thousand UAH/person, which falls to the capital of Ukraine, exceeds the worst – 14.3 thousand UAH/person, which falls to the Lugansk region, 13.5 times against the average regional level of 52 thousand UAH/person. This demonstrates a great difference in the economic development of the regional districts of Ukraine. Disproportions in the well-being of the population are smaller: the income of the population per person in Kyiv (128.1 thousand UAH/person) is 5.6 times higher than the income per person in Lugansk region (22.8 thousand UAH/person).

Based on the comparative analysis on the indicators of efficiency of implementation and decentralisation of fiscal policy (see Appendix A), it was not possible to realise the

ranking of the Ukrainian regions and the capital city of Kyiv. In this regard, Appendix B summarises the standardised indicators calculated by the formula (1) using the functionality of the Statistica 12 software package. Standardisation of indicators is a necessary procedure, as the cluster analysis requires evaluation of the so-called Euclidean distances between clusters and objects within clusters, the quantitative characteristics of which should be the same. Given the fact that among the indicators, on the basis of which clustering of administrative-territorial units according to the criteria of fiscal policy implementation efficiency and decentralisation, there are indicators with different units of measurement, they should be brought to a common measurement scale by standardisation method so that each variable Var1–Var18 has a mean value equal to 0 and a standard deviation equal to 1.

Consequently, after conducting all the necessary procedures to standardise the indicator values in Appendix B, using Ward's minimum variance method, a hierarchical clustering is implemented by constructing a dendrogram (Figure 4).

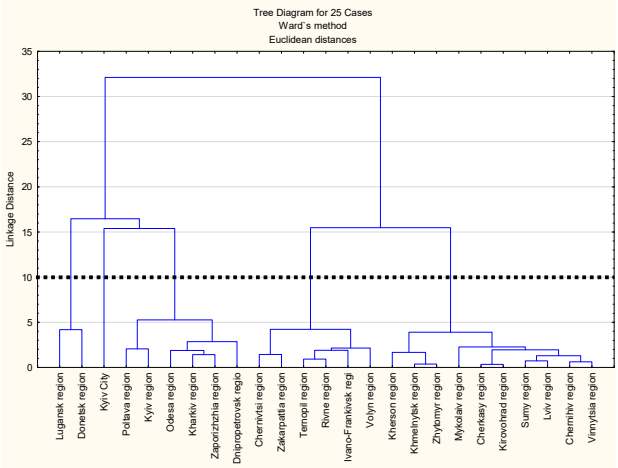

Fig. 4 Dendrogram of Ukrainian regions by level of effectiveness of implementation and decentralisation of fiscal policy in 2015–2019

Source: *Constructed using data from Appendix B by Statistica 12.*

The results of the clustering analysis of variance to estimate the distances between clusters are summarised in Table 1.

According to the results of Ward's analysis of variance clustering in Table 1, we can conclude that the differences between clusters are significant because for each of the studied attribute $p < 0.05$ and $F > 3.44$. This means that the results of cluster analysis are statistically significant and reliable.

The dendrogram of Ukrainian regions by level of fiscal policy effectiveness with respect to the results of decentralisation in 2015–2019, shown in Figure 4, forms 5 clusters if sliced at 10 Euclidean distance.

It should be noted that cluster analysis using the k-means clustering algorithm consists in the fact that the number of clusters is specified initially, while in Ward's minimum variance method the number of clusters is formed on the dendrogram (see Figure 4).

The need for the k-means clustering algorithm in Statistica 12 is due to the need for detailing which areas fall into which cluster, as the dendrogram does not show such a distribution (Table 2).

Table 1: Ward's clustering analysis of variance results

Indicator	Between SS	df	Within SS	df	F	signif. p
Var1	22.824	4	1.176	20	97.047	0.000000
Var2	19.006	4	4.994	20	19.031	0.000001
Var3	23.289	4	0.711	20	163.816	0.000000
Var4	10.160	4	13.840	20	3.671	0.021276
Var5	22.951	4	1.049	20	109.367	0.000000
Var6	17.291	4	6.709	20	12.887	0.000024
Var7	21.775	4	2.225	20	48.944	0.000000
Var8	22.802	4	1.198	20	95.129	0.000000
Var9	22.825	4	1.175	20	97.101	0.000000
Var10	19.074	4	4.926	20	19.359	0.000001
Var11	19.504	4	4.496	20	21.689	0.000000
Var12	22.134	4	1.866	20	59.299	0.000000
Var13	22.824	4	1.176	20	97.047	0.000000
Var14	22.682	4	1.318	20	86.081	0.000000
Var15	20.827	4	3.173	20	32.822	0.000000
Var16	22.380	4	1.620	20	69.067	0.000000
Var17	22.755	4	1.245	20	91.359	0.000000
Var18	23.439	4	0.561	20	208.956	0.000000

Source: *Constructed using data from Appendix B by Statistica 12.*

Table 2: Clustering of Ukrainian regions according to the k-means clustering algorithm

Cluster	Region
A	Donetsk, Lugansk
B	Vinnytsia, Zhytomyr, Kirovohrad, Lviv, Mykolaiv, Sumy, Kherson, Khmelnytsk, Cherkasy, Chernihiv
C	Dnipropetrovsk, Zaporizhzhia, Kyiv, Odesa, Poltava, Kharkiv
D	Volyn, Zakarpattia, Ivano-Frankivsk, Rivne, Ternopil, Chernivtsi
E	Kyiv Capital City

Source: *Constructed using data from Appendix B by Statistica 12.*

At the final stage of implementation of the methodological toolkit of clustering the regions of Ukraine to assess the effectiveness of implementation and decentralisation of fiscal policy at the level of administrative-territorial units we will conduct ranking of clusters. This involves grouping areas into clusters according to Table 1 and Figure 4, and calculating the average values of the 18 indicators for each cluster (Table 3).

Since in cluster analysis all attributes are equal, because their importance distribution is not specified, as, for example, in the integral evaluation method [28], it is sufficient to apply the sum of places method for ranking and ranking clusters. To implement the sum-of-the-places method, the data in Table 3 should be used to assign each cluster an appropriate ranking from 1 to 5 within the 18 indicators, taking into account whether they are stimulants or dis-stimulants.

Once all cluster locations from 1 to 5 for each attribute Var1–Var18 have been determined, a procedure

is carried out to sum up the assigned locations for each cluster and rank the clusters according to the minimax principle – the best cluster whose sum of locations is the smallest (Table 4).

Table 3: Cluster average values of fiscal policy indicators at the level of administrative-territorial units of Ukraine

Indicator	Cluster A	Cluster B	Cluster C	Cluster D	Cluster E
Var1	0.439	0.385	0.503	0.299	0.715
Var2	1.047	1.013	1.012	1.014	1.040
Var3	0.791	0.628	1.018	0.426	2.508
Var4	0.083	0.081	0.075	0.085	0.049
Var5	1.856	3.686	5.071	2.806	9.791
Var6	0.066	0.077	0.088	0.068	0.076
Var7	0.149	0.200	0.176	0.227	0.107
Var8	0.460	0.390	0.509	0.303	0.744
Var9	0.588	0.623	0.503	0.712	0.297
Var10	0.046	0.013	0.012	0.014	0.039
Var11	0.184	0.209	0.147	0.280	0.066
Var12	3.963	9.451	9.947	9.259	13.168
Var13	0.562	0.615	0.497	0.702	0.285
Var14	1.302	1.604	0.992	2.354	0.399
Var15	0.110	0.131	0.074	0.199	0.020
Var16	2.300	5.886	5.000	6.585	3.904
Var17	24.217	45.486	69.269	33.675	198.588
Var18	27.811	47.922	57.489	41.397	128.059

Source: *Constructed using data from Appendix B by Statistica 12.*

Consequently, each cluster is characterised from worst to best on the basis of the data shown in Table 4 in terms of the effectiveness of implementation and decentralisation of fiscal policy.

Table 4: Ranking of average cluster values of fiscal policy indicators at the level of administrative-territorial units of Ukraine

Indicator	Clusters:				
	A	B	C	D	E
Var1	3	4	2	5	1
Var2	1	4	5	3	2
Var3	3	4	2	5	1
Var4	2	3	4	1	5
Var5	5	3	2	4	1
Var6	5	2	1	4	3
Var7	4	2	3	1	5
Var8	3	4	2	5	1
Var9	3	4	2	5	1
Var10	1	4	5	3	2
Var11	3	2	4	1	5
Var12	2	4	3	5	1
Var13	3	4	2	5	1
Var14	3	4	2	5	1
Var15	3	4	2	5	1
Var16	1	4	3	5	2
Var17	5	3	2	4	1
Var18	5	3	2	4	1
Sum of places	55	62	48	70	35
Cluster rank	**3**	**4**	**2**	**5**	**1**

Source: *Constructed using data from Appendix B by Statistica 12.*

Cluster D. Considers all western Ukrainian regions except Lviv: Volyn, Zakarpattia, Ivano-Frankivsk, Rivne, Ternopil and Chernivtsi. This cluster is home to 16 % of Ukraine's population (1,134 thousand people on average per region), whose income accounts for 12.6 % (47 billion UAH on average per region) of Ukraine's total population. At the same time, 9.3 % of GRP is produced (38.6 billion UAH per region on average), 10.8 % of own revenues (3.2 billion UAH per region) is transferred to the consolidated regional budgets, and 16.4 % of expenditures are financed (10.5 billion UAH per region), resulting in 6 regions receiving 21 % of all transfers from the state budget of Ukraine (7.5 billion UAH per region). The regions in cluster D are the most subsidised, as they have the worst results in the efficiency of implementation of inter-budgetary relations and the worst values of financial sustainability and independence ratios. Their contribution to GRP production is the lowest, hence the highest ratios of revenues, expenditures and transfers of consolidated regional budgets to GRP. Consequently, the western Ukrainian regions, with the exception of Lviv, are characterised by the worst implementation of fiscal policy and financial decentralisation. Among the state modernization measures that need to be developed to save the situation, we will name the following: improving the investment climate to attract capital investment, facilitating business conditions and stimulating entrepreneurial initiative, legalizing the income of individuals and entrepreneurs, which will lead to the creation of new jobs, an increase in the volume of declared income of individuals, an increase in the income of individuals – entrepreneurs and income of enterprises, and as a result will ensure an increase in revenues from personal income tax, single tax and corporate income tax and reduce dependence on transfers from the state budget.

Cluster B. The largest in terms of the number of administrative-territorial units. Includes Vinnytsa, Zhytomyr, Kirovohrad, Lviv, Mykolaiv, Sumy, Kherson, Khmelnytskyi, Cherkasy and Chernihiv regions. This cluster is home to 23 % of Ukraine's population (1,305 thousand people on average per region), whose income accounts for 27.7 % (UAH 62.3 billion on average per region) of Ukraine's total population income. At the same time, 24.1 % of GRP is produced (60.4 billion UAH per region), 27 % of own revenues (4.8 billion UAH per region), and 32 % of expenditures (12.3 billion UAH per region) are financed, resulting in 10 regions receiving 36 % of all transfers from the state budget of Ukraine (7.7 billion UAH per region). This cluster includes most of Ukraine's agrarian-oriented regions, but it is not substantially inferior to Cluster D in terms of the effectiveness of fiscal policy implementation and financial decentralisation. The provincial consolidated budgets are also highly subsidised, so modernisation measures are needed to ensure that the share of own revenues increases due to growth in personal income and the income of entrepreneurs who pay a single tax. The gradual abolition of preferential taxation for producers of agricultural products would also be advisable as a special modernisation measure of fiscal policy.

Cluster A. Includes Donetsk and Luhansk regions, part of whose territories are occupied. This cluster is home to 15 % of Ukraine's population (3,211 thousand people on average per region), whose income accounts for 8.4 % (94.4 billion UAH on average per region) of Ukraine's total population income. It produces 7.1 % of GRP (88.3 billion UAH per region), receives 7.4 % of own revenues (6.5 billion UAH per region), and finances 7 % of expenditures (13.5 billion UAH per region), resulting in 2 regions receiving 7.2 % of all transfers from the state budget of Ukraine (7.7 billion UAH per region). Cluster A includes mining-oriented regions. However, the temporary occupation of parts of Donetsk and Luhansk regions as well as the United Forces Operation – real combat operations need to be taken into account in developing measures to improve implementation and decentralisation of fiscal policy. It would be advisable for the development of frontline areas to introduce preferential taxation for small and medium-sized businesses, while increasing the percentage of revenues from personal income tax and excise tax, which should remain in local and regional budget revenues, as part of the modernisation of fiscal policy.

Cluster C. Includes the most industrially developed regions Dnipropetrovsk, Zaporizhzhia, Kyiv, Odesa, Poltava and Kharkiv. This cluster is home to 31.1 % of Ukraine's population (an average of 2,206 thousand people per region), whose income accounts for 34.2 % (an average of UAH 128 billion per region) of the total income of the Ukrainian population. At the same time, 36.3 % of GRP is produced (151.5 billion UAH per region), 38 % of own revenues (11.2 billion UAH per region), and 34 % of expenditures (21.8 billion UAH per region) are allocated to the regional budgets, which results in 6 regions receiving 30.4 % of all transfers from the state budget of Ukraine (10.8 billion UAH per region). In order to increase the efficiency of implementation of fiscal policy of cluster C areas it is necessary to take advantage of their industrial orientation and provide conditions for ease of doing business and creating additional jobs, increasing the welfare of employees, stimulating foreign economic activities, production and sale of excisable goods. These measures will ensure increased revenues to local and regional budgets from the single tax, personal income tax, excise tax, etc.

Cluster E. Counts only the capital city of Ukraine, Kyiv. This cluster is home to 6.9 % of Ukraine's population (2,921 thousand people), whose income accounts for 16.6 % (374 billion UAH) of the total income of Ukraine's population. It produces 23.2 % of the GRP (580.1 billion UAH), receives 16.2 % of its own revenues (28.6 billion UAH), and finances 10 % of its expenses (38.5 billion UAH), resulting in 5.3 % of all transfers from the State Budget of Ukraine (11.4 billion UAH). The high efficiency of fiscal implementation and decentralisation in Kiev stems from the special fiscal status of the capital, which should be left for future development.

4. Conclusion

The necessity of application of clustering algorithms to ensure the reliability of fiscal policy evaluation and to stimulate its modernisation with the aim of enhancing financial decentralisation of administrative-territorial units has been substantiated. On the basis of Ward's minimum variance method and k-means clustering algorithm the financial clustering of 24 regions of Ukraine and Kyiv capital was conducted. As a result, 5 homogeneity clusters of 7 indicators of the fiscal component of the fiscal policy in conditions of financial decentralisation, 5 indicators of the expenditure component of the fiscal policy in conditions of financial decentralisation, 4 indicators of the state inter-budget relations in conditions of financial decentralisation and 2 indicators of the regional development efficiency were obtained. The main directions of modernisation of fiscal policy for each cluster have been developed and proposed, the implementation of which will ensure greater financial decentralisation and increase the efficiency of fiscal policy implementation at the regional level, and will also contribute to further decentralisation of public finances of administrative-territorial units.

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Appendix A

Annual averages of the efficiency of implementation and decentralisation of fiscal policy in Ukraine by region for 2015–2019

Region name	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Var9	Var10	Var11	Var12	Var13	Var14	Var15	Var16	Var17	Var18
Cherkasy	0.393	1.014	0.649	0.076	3.885	0.083	0.212	0.399	0.615	0.014	0.190	9.741	0.607	1.542	0.117	5.990	51.229	46.627
Chernivtsi	0.298	1.019	0.425	0.103	2.654	0.067	0.224	0.304	0.715	0.018	0.338	8.727	0.702	2.350	0.241	6.237	25.840	39.781
Chernihiv	0.378	1.013	0.607	0.080	3.657	0.077	0.205	0.382	0.630	0.012	0.209	9.566	0.622	1.649	0.132	6.029	45.694	47.286
Dnipropetrovsk	0.549	1.003	1.217	0.071	5.753	0.089	0.162	0.551	0.453	0.003	0.128	10.449	0.451	0.822	0.058	4.729	81.454	64.528
Donetsk	0.480	1.054	0.924	0.069	2.381	0.073	0.151	0.506	0.548	0.052	0.136	4.704	0.520	1.083	0.075	2.578	34.533	32.781
Ivano-Frankivsk	0.294	1.009	0.416	0.069	2.788	0.064	0.217	0.296	0.713	0.009	0.234	9.409	0.706	2.406	0.167	6.708	40.199	43.850
Kharkiv	0.480	1.014	0.921	0.074	4.360	0.080	0.166	0.486	0.528	0.014	0.152	8.968	0.520	1.085	0.080	4.732	58.954	54.771
Kherson	0.369	1.017	0.585	0.087	3.242	0.072	0.195	0.375	0.642	0.017	0.231	8.638	0.631	1.710	0.148	5.544	37.423	45.116
Khmelnytsk	0.355	1.010	0.550	0.084	3.421	0.072	0.203	0.359	0.651	0.010	0.234	9.540	0.645	1.817	0.153	6.215	40.753	47.541
Kirovohrad	0.394	1.014	0.651	0.080	3.850	0.083	0.210	0.400	0.614	0.014	0.201	9.628	0.606	1.536	0.124	5.913	47.847	46.591
Kyiv city	0.715	1.040	2.508	0.049	9.791	0.076	0.107	0.744	0.297	0.039	0.066	13.168	0.489	0.956	0.070	5.330	198.588	128.059
Kyiv	0.511	1.028	1.046	0.073	5.576	0.098	0.191	0.526	0.503	0.027	0.139	10.606	0.285	0.399	0.020	3.904	76.558	57.164
Lugansk	0.397	1.040	0.658	0.096	1.330	0.058	0.147	0.413	0.628	0.039	0.232	3.222	0.603	1.521	0.145	2.022	13.901	22.840
Lviv	0.407	1.009	0.687	0.082	3.920	0.078	0.192	0.411	0.598	0.009	0.199	9.540	0.593	1.456	0.119	5.709	47.964	50.147
Mykolaiv	0.420	1.019	0.725	0.075	3.819	0.078	0.185	0.428	0.591	0.019	0.176	8.918	0.580	1.379	0.104	5.268	50.601	49.117
Odesa	0.509	1.008	1.036	0.092	4.741	0.087	0.172	0.513	0.495	0.008	0.179	9.248	0.491	0.966	0.089	4.578	51.712	54.258
Poltava	0.475	1.016	0.905	0.060	5.124	0.094	0.197	0.482	0.533	0.015	0.125	10.619	0.525	1.105	0.067	5.663	85.148	54.691
Rivne	0.301	1.012	0.430	0.082	2.973	0.067	0.224	0.304	0.708	0.012	0.271	9.766	0.699	2.326	0.192	6.915	36.034	44.192
Sumy	0.392	1.009	0.646	0.086	3.812	0.075	0.192	0.396	0.613	0.009	0.218	9.629	0.608	1.549	0.134	5.903	44.095	50.638
Ternopil	0.283	1.013	0.394	0.081	2.603	0.064	0.227	0.286	0.727	0.012	0.284	9.098	0.717	2.540	0.207	6.610	31.983	40.609
Vinnytsia	0.388	1.015	0.634	0.079	3.792	0.077	0.198	0.394	0.621	0.015	0.200	9.628	0.612	1.577	0.124	5.979	48.139	49.263
Volyn	0.317	1.017	0.465	0.081	3.197	0.076	0.238	0.323	0.694	0.017	0.252	9.902	0.683	2.151	0.175	6.876	39.236	42.276
Zhytomyr	0.354	1.009	0.549	0.084	3.462	0.074	0.208	0.357	0.651	0.009	0.236	9.685	0.646	1.822	0.153	6.308	41.117	46.890
Zakarpattia	0.298	1.016	0.425	0.091	2.620	0.070	0.233	0.303	0.713	0.015	0.301	8.649	0.702	2.352	0.214	6.163	28.756	37.675
Zaporizhzhia	0.495	1.005	0.980	0.079	4.871	0.082	0.165	0.497	0.507	0.005	0.159	9.794	0.505	1.020	0.080	4.968	61.787	59.524
Average	0.410	1.017	0.761	0.079	3.905	0.077	0.193	0.417	0.600	0.017	0.204	9.234	0.590	1.565	0.127	5.475	52.782	50.249

** at the beginning of the year.*

Source: *Compiled and calculated from data given in [29]–[30].*

Appendix B

Standardised performance indicators for the implementation and decentralisation of Ukraine's fiscal policy by region for 2015–2019

Region name	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Var9	Var10	Var11	Var12	Var13	Var14	Var15	Var16	Var17	Var18
Cherkasy	–0.171	–0.246	–0.261	–0.298	–0.012	0.687	0.623	–0.177	0.155	–0.221	–0.220	0.276	0.171	–0.040	–0.195	0.424	–0.045	–0.197
Chernivtsi	–1.122	0.175	–0.783	2.126	–0.781	–1.021	1.013	–1.089	1.155	0.130	2.178	–0.276	1.122	1.392	2.107	0.627	–0.779	–0.570
Chernihiv	–0.321	–0.331	–0.359	0.061	–0.155	0.047	0.395	–0.340	0.305	–0.396	0.088	0.181	0.321	0.149	0.083	0.456	–0.205	–0.161
Dnipropetrovsk	1.391	–1.174	1.061	–0.747	1.153	1.328	–1.003	1.283	–1.465	–1.183	–1.225	0.662	–1.391	–1.317	–1.291	–0.614	0.829	0.778
Donetsk	0.700	3.128	0.379	–0.927	–0.951	–0.380	–1.360	0.851	–0.515	3.106	–1.095	–2.468	–0.700	–0.854	–0.975	–2.383	–0.527	–0.951
Ivano-Frankivsk	–1.163	–0.668	–0.804	–0.927	–0.697	–1.341	0.786	–1.166	1.135	–0.658	0.493	0.096	1.163	1.491	0.733	1.015	–0.364	–0.349
Kharkiv	0.700	–0.246	0.372	–0.478	0.284	0.367	–0.873	0.659	–0.715	–0.221	–0.836	–0.145	–0.700	–0.851	–0.882	–0.611	0.178	0.246
Kherson	–0.411	0.007	–0.410	0.690	–0.414	–0.487	0.070	–0.407	0.425	0.042	0.444	–0.325	0.411	0.257	0.380	0.057	–0.444	–0.280
Khmelnytsk	–0.552	–0.584	–0.492	0.420	–0.302	–0.487	0.330	–0.561	0.515	–0.571	0.493	0.167	0.552	0.447	0.473	0.609	–0.348	–0.147
Kirovohrad	–0.161	–0.246	–0.257	0.061	–0.034	0.687	0.558	–0.167	0.145	–0.221	–0.042	0.215	0.161	–0.051	–0.065	0.360	–0.143	–0.199
Kyiv city	3.054	1.947	4.066	–2.722	3.673	–0.060	–2.791	3.137	–3.025	1.968	–2.230	2.143	–3.054	–2.067	–1.996	–1.292	4.214	4.238
Kyiv	1.011	0.935	0.663	–0.567	1.043	2.289	–0.060	1.043	–0.965	0.917	–1.047	0.748	–1.011	–1.079	–1.068	–0.119	0.687	0.377
Lugansk	–0.131	1.947	–0.240	1.498	–1.607	–1.981	–1.490	–0.042	0.285	1.968	0.460	–3.275	0.131	–0.078	0.325	–2.841	–1.124	–1.493
Lviv	–0.031	–0.668	–0.173	0.241	0.009	0.154	–0.027	–0.061	–0.015	–0.658	–0.075	0.167	0.031	–0.193	–0.158	0.193	–0.139	–0.006
Mykolaiv	0.099	0.175	–0.085	–0.388	–0.054	0.154	–0.255	0.102	–0.085	0.217	–0.447	–0.172	–0.099	–0.329	–0.437	–0.170	–0.063	–0.062
Odesa	0.991	–0.753	0.639	1.138	0.522	1.114	–0.678	0.918	–1.045	–0.746	–0.399	0.008	–0.991	–1.061	–0.715	–0.738	–0.031	0.218
Poltava	0.650	–0.078	0.334	–1.735	0.761	1.862	0.135	0.620	–0.665	–0.133	–1.274	0.755	–0.650	–0.815	–1.124	0.155	0.935	0.242
Rivne	–1.092	–0.415	–0.771	0.241	–0.582	–1.021	1.013	–1.089	1.085	–0.396	1.092	0.290	1.092	1.350	1.197	1.185	–0.484	–0.330
Sumy	–0.181	–0.668	–0.268	0.600	–0.058	–0.167	–0.027	–0.206	0.135	–0.658	0.233	0.215	0.181	–0.028	0.120	0.352	–0.251	0.021
Ternopil	–1.273	–0.331	–0.855	0.151	–0.812	–1.341	1.111	–1.262	1.275	–0.396	1.303	–0.074	1.273	1.729	1.476	0.934	–0.601	–0.525
Vinnytsia	–0.221	–0.162	–0.296	–0.029	–0.070	0.047	0.168	–0.225	0.215	–0.133	–0.058	0.215	0.221	0.022	–0.065	0.415	–0.134	–0.054
Volyn	–0.932	0.007	–0.690	0.151	–0.442	–0.060	1.468	–0.907	0.945	0.042	0.784	0.364	0.932	1.039	0.882	1.153	–0.391	–0.434
Zhytomyr	–0.562	–0.668	–0.494	0.420	–0.276	–0.273	0.493	–0.580	0.515	–0.658	0.525	0.246	0.562	0.456	0.473	0.685	–0.337	–0.183
Zakarpattia	–1.122	–0.078	–0.783	1.049	–0.802	–0.700	1.306	–1.099	1.135	–0.133	1.578	–0.319	1.122	1.396	1.606	0.566	–0.694	–0.685
Zaporizhzhia	0.850	–1.006	0.509	–0.029	0.603	0.581	–0.905	0.765	–0.925	–1.008	–0.723	0.305	–0.850	–0.966	–0.882	–0.417	0.260	0.505

Source: *Formed and calculated by the data in Appendix A.*

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