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USING CLUSTER ANALYSIS TO ASSESS FINANCIAL STABILITY AS AN OBJECT OF MANAGERIAL IMPACT OF REGIONAL COMPETITIVE IMMUNITY

The main aspect in the study of the financial stability of the local budgets of the regions as a component of the competitive immunity of the region is the search for criteria and the development of a methodology for assessing efficiency. In accordance with the accepted concept of competitive immunity, three problem-area blocks have been highlighted as a means of its evaluation: informational and digital approach; information and digital technologies; value and reputational management, which include the objects of managerial influence considered for the assessment of bringing competitive immunity to sustainable functioning. The paper examines and classifies the regions of Ukraine according to the financial stability of the local budget into three groups: regions with high financial stability, regions with medium financial stability, and regions with low financial stability. The authors undertook an applied study to assess the financial stability of the budget as an object of managerial influence at the local level. The study was conducted on the basis of the local budget indicators of all regions of Ukraine for 2018-2020. The calculation of the selected indicators was carried out on the basis of statistical data on the implementation of local budgets, reports and decisions of regional councils on the regional budget. The suggested methodological approach is the basis for assessing the budget policy and financial stability of the region as an object of the managerial influence of competitive immunity. The distribution of the original data set across clusters in the study was carried out using the business analytical platform Deductor and clustering algorithms such as the k-means and Kohonen maps. It has been established that Kohonen maps and k-means based on the Deductor business analytics platform can be used to cluster Ukrainian regions based on indicators of financial stability. The interpretation of the findings with the help of a comprehensive analysis of financial stability based on local budget data allows not only to analyze the obtained values and give a predictive assessment, but also to justify the chosen strategy for strengthening the competitive immunity of the studied region.

Key words: competitive immunity, local budgets, modeling, competitiveness, regions, neural networks, clustering.

Головним у дослідженні фінансової стійкості місцевих бюджетів регіонів як складової конкурентного імунітету регіону є пошук критеріїв і розробка методики оцінки ефективності. Відповідно до прийнятого поняття конкурентного імунітету для його оцінки у статті виділено три блоки: інформаційно-цифровий підхід; інформаційні та цифрові технології; вартісне та репутаційне управління, які включають об'єкти управлінського впливу, що розглядаються для оцінки приведення конкурентного імунітету до стійкого функціонування. У даній роботі розглянуто та згруповано регіони України за фінансовою стійкістю місцевого бюджету у три групи: регіони з високою фінансовою стійкістю, регіони із середньою фінансовою стійкістю та регіони з низькою фінансовою стійкістю. Прикладне дослідження для оцінки фінансової стійкості бюджету як об'єкта управлінського впливу на місцевому рівні проводилось на прикладі показників місцевих бюджетів усіх регіонів України за 2018-2020 роки. Розрахунок обраних показників здійснено на основі статистичних даних про виконання місцевих бюджетів, звітів та рішень обласних рад про обласний бюджет. Досліджений методичний підхід є основою для оцінки бюджетної політики та фінансової стійкості регіону як об'єкта управлінського впливу конкурентного імунітету. Розподіл вихідного набору даних на кластери у дослідженні здійснювався за допомогою бізнес-аналітичної платформи Deductor та таких алгоритмів кластеризації як k-means та карт Кохонена. Встановлено, що карти Кохонена та кластеризацію алгоритмом k-means за допомогою бізнес-аналітичної платформи Deductor можна застосовувати для кластеризації українських регіонів за показниками фінансової стійкості. Інтерпретація результатів, отриманих за допомогою комплексного аналізу фінансової стійкості на основі даних місцевого бюджету, дозволяє не лише проаналізувати отримані значення та дати прогнозну оцінку, а також обґрунтувати обрану стратегію зміцнення конкурентного імунітету досліджуваного регіону.

Ключові слова: конкурентний імунітет, місцеві бюджети, моделювання, конкурентоспроможність, регіони, нейронні мережі, кластеризація.

Introduction. In modern conditions, the issues of assessing the stability of the financial system and strengthening competitive positions at the micro, meso and macro levels remain relevant for countries with different levels of development. Due to the differentiation of national financial systems, it is impossible to form a single list of indicators for an objective assessment of financial stability at the international level. The financial systems are different in terms of the level of development, structure, subjects and financial instruments. The relevance of considering financial stability and competitive immunity at the meso level is increasing due to events that give rise to problems both in the economic and social spheres. Given the inevitability of negative impacts and new socio-economic shocks, the provision and functioning of the financial stability mechanism at the regional level is a necessity faced by local governments and affecting the level and quality of life of the population. Competitive advantages and competitiveness of regions as a whole are mainly determined by the level of financial stability. The internal financial capabilities of the region affect the competitive policy of the territory, the level of competitive immunity and the possibility of strengthening competitive positions, which is typical for regions with a high level of financial stability. This relationship highlights financial stability as a factor of the competitiveness of the territory, and, accordingly, as an object of managerial impact of competitive immunity at the regional level. It should be also noted that the issues of competitiveness (in particular, competitive advantages), financial stability and their relationship are most studied at the micro level, less at the macro level. However, a more systematic and theoretical analysis is required for the problem of financial stability and competitive advantages the meso level.

Literature review. The literature review shows that the category of financial stability was successfully described by both domestic and foreign scientists. Despite the fact that there are many definitions of financial stability, a significant part of them follow the definition below in general terms.

According to the definition of the European Central Bank [1], financial stability is considered as a state in which the financial system as a whole can withstand emerging shocks in order to reduce the likelihood of failures in financial intermediation processes that are severe enough to cause serious disturbances in the financial system. In more detail, the financial system according to [2] is presented as a stable system that can efficiently allocate resources, manage financial risks associated with the financial system, and eliminate unwanted fluctuations in the prices of real or financial assets that may affect the stability of monetary policy. Financial imbalances that arise endogenously or due to unforeseen events are also eliminated in a stable financial system. In the event of shocks, the system will be cushioned by self-correcting mechanisms that will prevent adverse factors from hurting the real economy and other financial systems. Financial stability is an important policy element in terms of achieving sustainable economic growth, since most transactions in the economy are carried out through the financial system.

The concept of "competitive immunity of a territor" reflects a number of new characteristics of modern territorial-regional-interregional competition in the global economy, which essentially distinguishes it from the concept of economic security at the macro- and mesolevels [3]. The explanation of internal reserves for the survival of the peripheral territories of the regions of Ukraine is possible by introducing a new universal category «territory immunity» [4]. Under the category "general immunity of the region" introduced by the authors, it is proposed to consider natural conditions, the specifics of the formation of the economic complex and infrastructure of the region from the point of view of a combination of "innate" and "acquired" conditions in order to create conditions for economic growth and the implementation of economic cycles. That is, the competitive immunity of a territory primarily illustrates the ability of a territory to successfully compete with other territories, but also implies its ability to withstand possible risks (both internal and external), having resources, assets and a strategic plan to recover from destructive events [5].

The concept of "competitive immunity" can be found in the studies of a group of scientists: S. Vazhenin, I. Vazhenina, A. Tatarkina, D. Kopantseva. Competitive immunity is becoming a new, modern category of competitive advantage. According to I. Vazhenina and S. Vazhenin, competitive immunity involves the construction of an effective system for ensuring economic security and protecting the interests of the territory [6]. An arbitrary set of indicators cannot be the basis for an accurate and objective assessment of the level of development of the territory, given that not all selected and used indicators can be called statistically significant relative to the resulting indicator. This suggests that assessment of the competitive immunity of the region should involve a careful selection of components and indicators that adequately reflect the socio-economic situation of the region and the quality of life of the population.

In accordance with the accepted concept of competitive immunity, it is proposed to single out three problem-area blocks (means) for its assessment – information-digital approach; information and digital technologies; cost and reputation management, which include objects of managerial influence necessary to assess the transformation of competitive immunity to sustainable functioning (Fig. 1).

Each of the blocks requires careful study, selection of indicators that reflect a specific object of managerial influence. To identify the factors most influencing the state of competitive immunity for each block of indicators, it is proposed to build econometric models and conduct a statistical analysis. This study involves a detailed consideration and applied research of financial stability as one of the most significant components of the competitive immunity of the region. The main aspect in the study of the financial stability of the local regional budgets as an integral part of the region's competitive immunity is the search for criteria and the development of a methodology for evaluating efficiency. With regard to the financial aspect of the regions, efficiency implies the desire

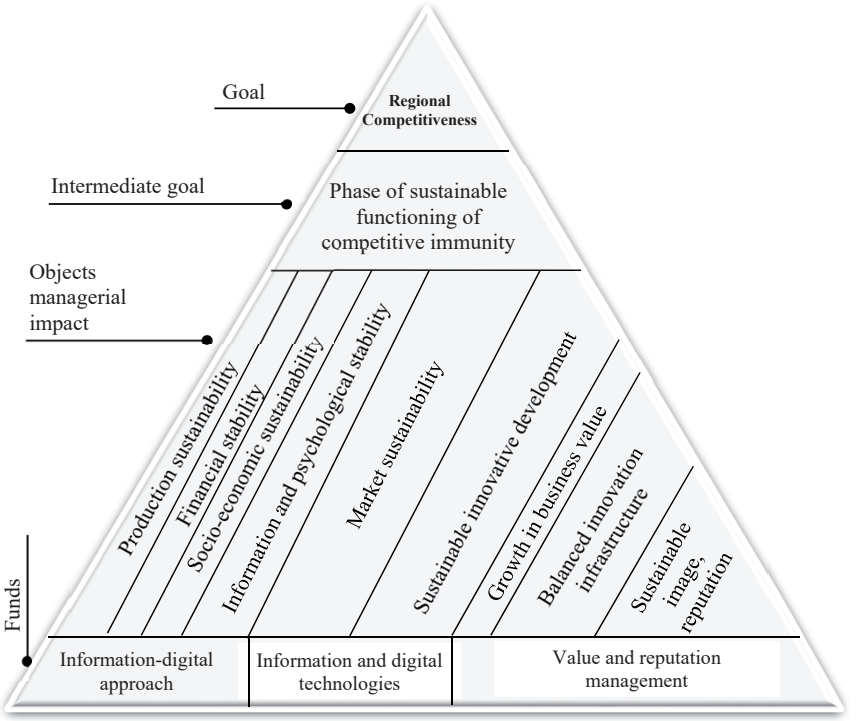

Fig. 1. The role of sustainability of competitive immunity in building the competitiveness of the region

to achieve the goals set on the basis of the national system of values and the objectives of economic development through the provision of services, achieving the maximum result, using a certain amount of the budget, thereby minimizing the amount of budget funds attracted. Existing approaches to assessing financial stability and its effectiveness are divided into one-dimensional and complex approaces.

Methodology. The criteria for evaluating one-dimensional approaches are aimed at a variety of characteristics, such as: a positive effect from the results of activities, productivity, manageability, goal achievement, etc. This approach is characterized by the calculation of one complex (integral) indicator, which reflects the state of the processes under study. Most often, when considering the methodology for an integral assessment of the financial condition of the budget in order to analyze its effectiveness, an interconnected treatment of income, expenses and accounts payable for a specific period is used. The effectiveness of this approach is as follows: the greater income and the lower costs are, the greater value is, at the same time, a decrease in accounts payable indicates a positive value, and, accordingly, an improved financial condition of the budget. In this study, the use of such an approach is not appropriate since it reflects a limited number of factors, affecting the effectiveness of the budget policy of local budgets. For a more objective assessment of the results of financial stability as an object of managerial impact of competitive immunity at the regional level, a set of multidimensional methods was chosen based on the calculation of selected indicators for assessing the state of local budgets. The difficulty of using multidimensional analysis of the financial stability of the local budgets is manifested both in the choice of financial indicators that can correctly reflect the balance of the local budget, its sustainability and efficiency, and in the possibility of their use in practice. Considering all of the above and based on the research of M. Stegney, I. Lintur [7] the authors used the following performance indicators for local budgets:

– budget revenues;
– budget expenditures;
– intergovernmental transfers from the state budget;
– tax revenues;
– amount of equalization subsidies;
– non-tax revenues;
– the average population.

The specification of indicators proposed by L. Kostirko [8] is aimed at providing an objective assessment of the local budget using blocks of analysis of the balance of the local budget, its efficiency and financial stability. The integral indicator of the financial stability of the local budget is formed as the sum of aggregated normalized indicators for blocks of analysis, taking into account the significance of the indicators and the significance of each block of analysis.

The advantage of this technique is manifested in the possibility of using the calculated value of the integral performance indicator as a lever when ranking the local budget rating among other regional budgets, which will allow assessing the positions for each region, identifying both strong and weak groups, and providing proposals for a development strategy for the local budget as a subsystem of a competitive immunity of the region in order to strengthen or improve the competitive position of the territory. Also, this methodology, in the context of the study, allows at the regional level to identify ways to improve the formation and implementation of the budgetary policy of local governments with a focus on strengthening the competitive immunity of the region through an information-digital approach. Based on the fact that the existing methods for assessing the effectiveness of budget policy do not assess the level of achievement of the necessary goals and do not determine by what criterion the assessment of local budgets can be considered effective, a comprehensive analysis will provide information that allows to make decisions both in terms of the formation of budget policy, improving its effectiveness, and in terms of the development of a strategy for the formation of a model of competitive immunity in the region. An analysis of existing methods and indicators has led to the fact that the most adapted for the current study with a certain level of significance is the system of indicators for a comprehensive analysis of the local budget (Fig. 2), proposed by L. Kostirko [8].

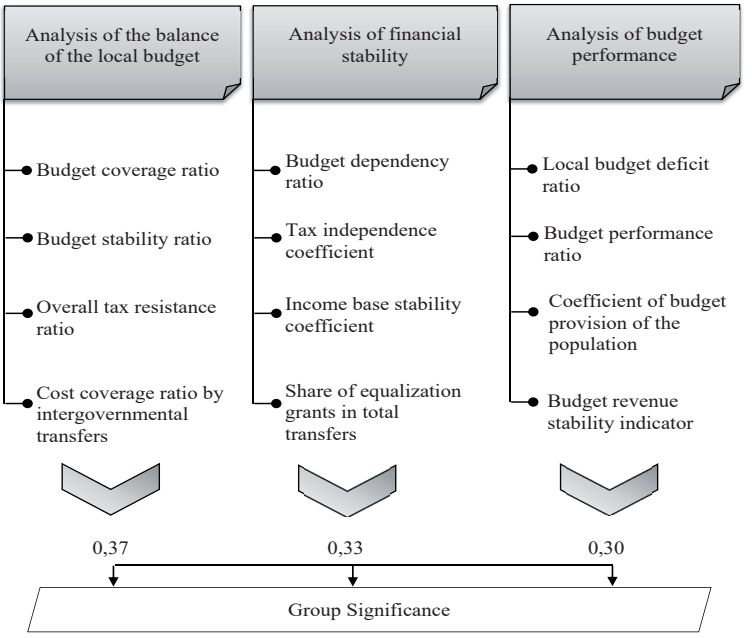

Fig. 2. Selected indicators for a comprehensive analysis of the local budget

Calculation of the integral indicator of the financial stability of the local budget according to the methodology proposed by L. Kostirko [8] is completed as the sum of aggregated standardized indicators for each of the existing blocks of analysis, considering certain weights for each block:

$$IP_{fs} = (SI_{fb} \cdot w_{fb}) + (SI_{fi} \cdot w_{fi}) + (SI_{lbe} \cdot w_{ibe}),$$

where IP_{fs} – is an integral indicator of the financial stability of the local budget of the region;

SI_{fb} – a standardized indicator for the block of financial balance of the region;

SI_{fi} – a standardized indicator for the block of financial independence of the region;

SI_{ibe} – is a standardized indicator for the block of local budget efficiency;

w_{fb}, w_{fi}, w_{ibe}, are the weights of the indicator for the block of the financial balance of the region, the financial independence of the region and the efficiency of local budgets, respectively.

An applied study of this methodology for assessing the financial stability of the budget as an object of managerial influence at the local level is carried out according to a similar algorithm using the indicators of local budgets of all regions of Ukraine for 2018-2020 as an example. The calculation of the selected indicators was made on the basis of statistical data on the execution of local budgets, reports and decisions of regional councils on the regional budget.

The distribution of the initial data set from Table 1 across clusters was carried out with the help of the Deductor business analytical platform and clustering algorithms such as the *k*-means algorithm and Kohonen maps.

As far as we know, very few studies have measured the real impact of clusters and cluster policy [9, 10, 11]. The first problem is to accurately determine the geographical boundaries of clusters and the industries that compete in these clusters [12]. When solving this problem, a second one arises – related to methodologies and measurement tools that assess the impact of clusters on the economic development of regions [13].

The business analytical platform Deductor allows to display the clustering process using a multidimensional data representation – an OLAP cube; also, any data that is used in the program can be analyzed using cross tables and cross charts, as well as using Kohonen maps and the resulting cluster profiles.

The main task of multidimensional cluster analysis is to split a set of objects in a multidimensional space into clusters containing similar objects according to given characteristics. At the same time, elements from different clusters should differ from each other.

The *k*-means algorithm is based on the following algorithm:

1. Determining the number of *k* and *k* points – the centers of gravity of clusters in the multidimensional space of factors.

2. Each of the elements of the sample will be close to one of the centers of gravity. We believe that not all elements approach a single center, i.s. more than one cluster.

3. Based on the data on the elements of each group, the value of the cluster centers is calculated, which become the new centers of gravity. The cluster center is calculated as the average value of the vectors - objects included in the given group.

4. For new values of the centers of gravity, new groups of elements are formed.

5. If the new group of elements does not differ from the previous one with a given error, steps 3-5 of this algorithm are repeated. The iterative process can also be stopped by reaching the limit of the number of iterations specified by the user.

Import of the initial sample assumes one information field (regions) and input fields (coefficient values). The number of clusters – clusters – was chosen manually, following the following considerations: when the obtained coefficients are standardized and a smaller number of clusters is chosen, the probability of erroneous identification of a cluster increases due to the existing range of values. The selected number of clusters makes it possible to assess the situation as a whole and, if necessary, combine clusters, narrowing their number and defining the area in one of the categories: high financial stability, medium financial stability, low financial stability. When clustering Ukrainian regions by financial stability ratios for 2018-2020. Connections of existing clusters in Figure 3 were obtained, and the results of the analysis presented in Table 2.

Table 1

Results of a comprehensive analysis of the financial sustainability of local budgets of the regions of Ukraine for 2018-2020*

Region	SI_{fb}	SI_{fi}	SI_{ibc}	SI_{fb}	SI_{fi}	SI_{ibc}	SI_{fb}	SI_{fi}	SI_{ibc}
	2018			2019			2020		
Vinnitsa region	0,53	0,20	0,03	0,36	0,11	0,57	0,42	0,26	1,12
Volyn region	0,47	0,13	0,64	0,54	0,20	0,04	1,12	0,52	0,29
Dnipropetrovsk region	0,37	0,21	1,47	0,41	0,33	1,66	0,50	0,69	3,55
Donetsk region	0,53	0,22	0,06	0,32	0,02	0,00	0,46	0,02	0,13
Zhytomyr region	0,51	0,57	0,16	0,48	0,54	0,29	0,53	0,51	0,83
Zakarpattia region	0,54	0,22	0,01	0,57	0,23	0,03	0,52	0,27	0,07
Zaporizhzhia region	0,53	0,21	0,00	0,89	0,24	0,39	1,47	0,06	1,09
Ivano-Frankivsk region	0,31	0,01	0,00	0,49	0,10	0,07	0,55	0,04	0,19
Kyiv region	0,72	0,23	0,20	0,63	0,27	0,16	0,48	0,34	0,22
Kirovohrad region	0,20	0,09	0,37	0,41	0,11	0,49	0,52	0,27	0,93
Luhansk region	0,54	0,22	0,02	0,49	0,22	0,00	0,49	0,30	0,04
Lviv region	0,61	0,24	0,12	0,58	0,23	0,08	0,60	0,17	0,16
Mykolaiv region	0,58	0,23	0,07	0,59	0,24	0,08	0,77	0,31	0,31
Odesa region	0,55	0,24	0,24	0,54	0,25	0,07	0,64	0,34	0,27
Poltava region	0,55	0,24	0,07	0,54	0,27	0,11	0,50	0,33	0,19
Rivne region	0,35	0,19	1,08	0,41	0,13	0,14	0,54	0,28	0,27
Sumy region	0,31	0,11	0,24	0,39	0,16	0,17	0,40	0,19	0,23
Ternopil region	0,58	0,21	0,03	0,60	0,24	0,06	0,63	0,37	0,19
Kharkiv region	0,53	0,23	0,06	0,50	0,25	0,07	0,51	0,32	0,30
Kherson region	0,53	0,19	0,03	0,53	0,21	0,04	0,51	0,08	0,08
Khmelnytsky region	0,80	0,20	0,26	0,61	0,23	0,11	0,78	0,29	0,33
Cherkasy region	0,56	0,22	0,04	0,55	0,24	0,05	0,54	0,30	0,13
Chernivtsi region	0,57	0,22	0,03	0,12	0,36	-0,05	0,52	0,32	0,04
Chernihiv region	0,55	0,20	0,04	0,57	0,25	0,06	0,57	0,32	0,23
Kyiv City	0,04	0,30	0,09	0,51	0,38	0,98	0,50	0,40	1,95

*Data are indicated without taking into account the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and without part of the temporarily occupied territories in the Donetsk and Lugansk regions.

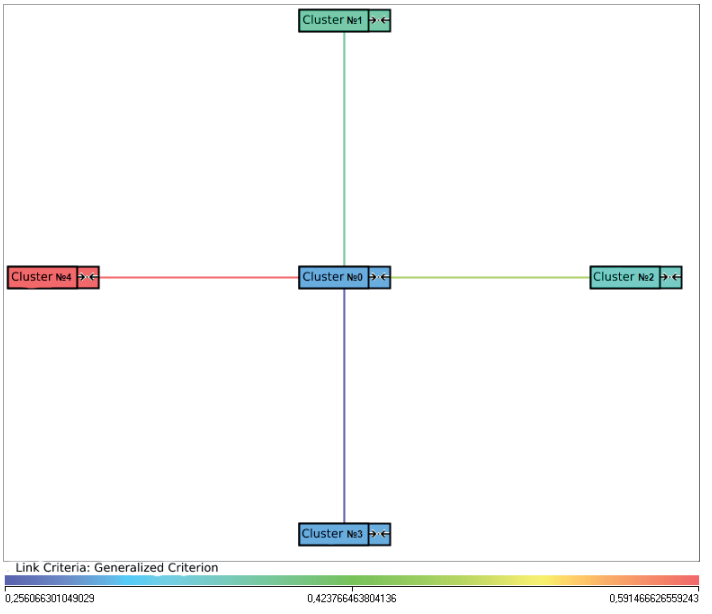

Fig 3. Relationships between 5 automatically built clusters

Fig.4 shows cluster profiles that allow to assess the impact of each of the indicators characterizing financial stability within the cluster in terms of the «Significance» indicator. Significance equals (1- *a*) ×100%, where *a* is the probability of the null hypothesis.

Based on the obtained profiles, it can be observed that the standardized indicator for the financial balance block of the region is the most significant for groups 4 and 5; standardized indicator for the block of financial independence of the region, significant for groups 1, 2 and 3; and the standardized indicator for the efficiency block of local budgets is significant for groups 1 and 0. This information will help prioritize when choosing a strategy for forming a model of competitive immunity of the region, as it shows weaknesses in the formation and distribution of the local budget of the regions of Ukraine.

Table 2

Visualization of the received data using a cube (OLAP analysis)

Region	0	1	2	3	4	Total:
Vinnitsa region		1		1	1	3
Volyn region	1	1			1	3
Dnipropetrovsk region				3		3
Donetsk region		2			1	3
Zhytomyr region			3			3
Zakarpattia region					3	3
Zaporizhzhia region	2				1	3
Ivano-Frankivsk region		3				3
Kyiv region			1		2	3
Kirovohrad region		2			1	3
Luhansk region					3	3
Lviv region					3	3
Mykolaiv region	1				2	3
Odesa region			1		2	3
Poltava region			1		2	3
Rivne region		2			1	3
Sumy region		3				3
Ternopil region			1		2	3
Kharkiv region			1		2	3
Kherson region		1			2	3
Khmelnytsky region	2				1	3
Cherkasy region					3	3
Chernivtsi region			1		2	3
Chernihiv region					3	3
Kyiv City			2	1		3
Total:	6	15	11	5	38	75

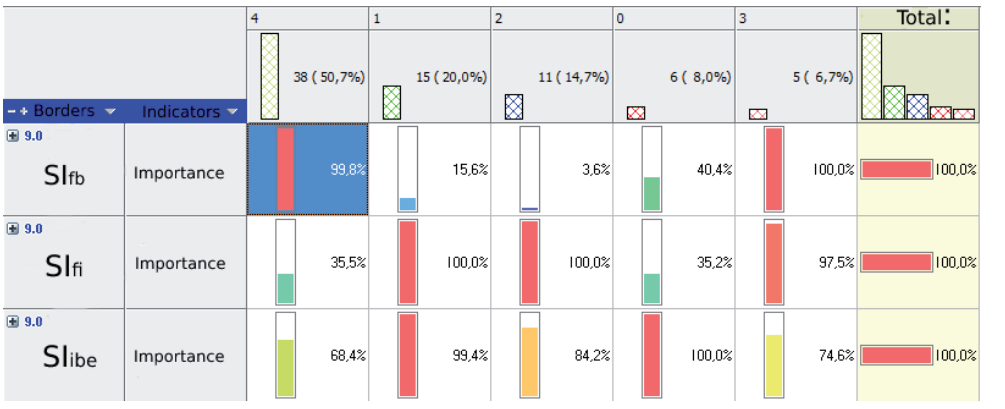

Fig. 4. Cluster profiles by calculated indicators

It follows from the resulting comparison matrix that it is possible to conditionally combine the second and third clusters, as well as the zero and fourth ones.

From the data in Table 2, it can be seen that the second and third clusters include completely Dnipropetrovsk, Zhytomyr, Sumy regions and the city of Kyiv for the entire study period of 2018-2020. The zero and fourth clusters include the entire Zaporizhzhia, Zakarpattia, Lugansk, Lviv, Mykolaiv, Khmelnitsky, Cherkasy and Chernihiv regions and almost intire Kyiv, Odesa, Poltava, Ternopil, Kharkiv, Kherson and Chernivtsi regions for the period 2018-2020. The first cluster fully contains only Ivano-Frankivsk region for 2018-2020. and fragmentarily Donetsk, Kirovograd, Rivne regions only for two studied periods.

Thus, based on the results of the *k*-means algorithm, it can be concluded that it is expedient to divide the sample for classifying regions into three clusters, each of which contains all or most of the data for the study period.

To compare and evaluate the effectiveness of the results obtained, as well as to supplement the analysis of the financial stability of the regions of Ukraine, Kohonen maps were used on the basis of the Deductor business analytical platform.

Kohonen's Self-Organizing Map (SOM) is a neural network that performs the task of multidimensional clustering and visualization of a multidimensional dataset [14]. A self-organizing map allows to display multidimensional objects as a set of two-dimensional maps that are compact and easy to view and analyze. The search for patterns in large data sets by training a neural network of retrospective data allows for an exploratory multivariate analysis of data samples that differs from classical statistical data analysis procedures. The result is manifested in the resulting projection of the multidimensional data space onto a set of two-dimensional maps, on which neurons are ordered under color according to the scale of a separate fixed data attribute of each map.

The learning process of a neural network involves choosing sufficiently large values and a learning radius. The learning radius, in turn, determines the number of neurons that take part in learning at the considered iteration and decrease down to one neuron. After that, the weight coefficients $r_i(t_j)$ are calculated along with a decrease in the values of the learning rate function and the learning radius.

The Kohonen's maps were applied to solve the problem of clustering regions of Ukraine according to the previously selected indicators that characterize the financial stability of local budgets. The obtained statistical characteristics of each cluster for each factor show that the first factor is significant for the zero and third clusters (100%), the second factor – for the zero, first and second clusters (99,4%-100%), the third factor – for the fourth and the third cluster (99,9%-100%).

Figure 5 shows the Kohonen maps for the constructed clustering of regions with three clusters. It should be noted that one cluster is visually highlighted on each map. On the Clusters map, three colors show the location of nodes (network neurons) in five clusters.

The content of each of the resulting clusters is shown in Table 3. By analogy with the previous method, it follows from the obtained comparison matrix that it is possible to conditionally combine the second and third clusters, as well as the zero and fourth ones. From the data in Table 3 it can be seen that the second and third clusters contain the entire Dnipropetrovsk and Zhytomyr regions and partly the city of Kyiv for the study period 2018-2020. Zero and fourth clusters include the entire Zakarpattia, Ivano-Frankivsk, Lugansk, Lviv, Odesa, Poltava, Rivne, Sumy, Ternopil, Kharkiv, Kherson, Cherkasy, Chernivtsi, Chernihiv regions, as well as partially Zaporizhzhia, Kyiv, Vinnitsa, Volyn, Kirovohrad and Mykolaiv region for the period 2018-2020 The first cluster mainly included Khmelnytsky region for the study period of 2018-2020.

The resulting groups are considered as clusters with the following type of financial stability: high financial stability, medium financial stability, low financial stability,

where the second and third clusters together represent a set of financially stable regions, zero and fourth include regions with medium financial stability, the first includes unstable regions in terms of financial performance. The obtained results suggest that Kohonen's maps clearly show (Fig. 4) that the boundary between clusters is quite blurred and it is very difficult to identify a subtle difference between the G-means included in the regions, therefore, regions were identified that, when using these methods, were assigned to different clusters.

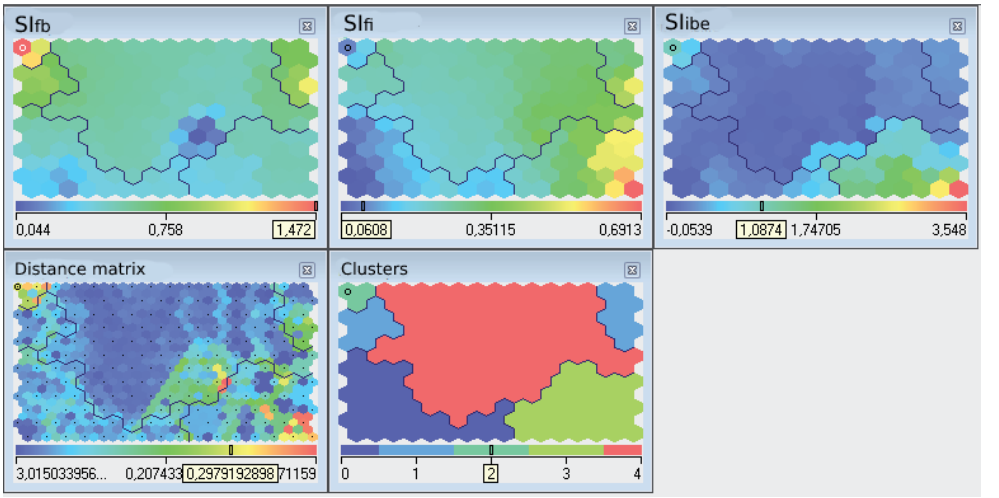

Fig. 5. Maps of Kohonen constructed from the point of view of the financial stability of the regions

Table 3

Visualization of the data obtained from Kohonen maps using a cube (OLAP analysis)

Region	0	1	2	3	4	Total:
Vinnitsa region	1			1	1	3
Volyn region	1	1			1	3
Dnipropetrovsk region				3		3
Donetsk region	2				1	3
Zhytomyr region			3			3
Zakarpattia region					3	3
Zaporizhzhia region		1	1		1	3
Ivano-Frankivsk region	3					3
Kyiv region		1			2	3
Kirovohrad region	2			1		3
Luhansk region					3	3
Lviv region					3	3
Mykolaiv region		1			2	3
Odesa region					3	3
Poltava region					3	3
Rivne region	2				1	3
Sumy region	3					3
Ternopil region					3	3
Kharkiv region					3	3
Kherson region	1				2	3
Khmelnytsky region		2			1	3
Cherkasy region					3	3
Chernivtsi region					3	3
Chernihiv region					3	3
Kyiv City				2	1	3
Total:	15	6	1	10	43	75

The results obtained show that the Dnipropetrovsk and Zhytomyr regions are the leaders and the most stable in terms of financial performance. The predominant number of regions was assigned to the group with an average financial stability of local budgets, namely: Donetsk, Zakarpattia, Lugansk, Lviv, Odesa, Poltava, Rivne, Sumy, Ternopil, Kharkiv, Kherson, Cherkasy, Chernivtsi, Chernihiv, Vinnitsa, Volyn, Zaporizhzhia, Kyiv, Kirovograd, Mykolaiv. The assignment of the Sumy region to this group instead of the group with high financial stability, as displayed when applying the *k*-means method, indicates that some of the indicators do not correspond to the standard value, which stands out against the background of absolutely stable regions. Also, when using the k-means method, a controversial situation occurred with Ivano-Frankivsk oblast, it was assigned to a group of regions with low financial stability, but Kohonen's maps assigned it to a group with medium stability. Indeed, when comparing the obtained coefficients of financial stability of the Ivano-Frankivsk region with the normative ones, it was revealed that the region has the smallest number of coefficients that correspond to the standard. The same is observed in the analysis of the Khmelnitsky region. Accordingly, due to the blurred border between clusters and fairly close values of the coefficients, it is difficult to determine the difference between the regions included in the cluster, so the possibility of classifying the region as a cluster with similar characteristics is not excluded.

Also, an integral indicator of the financial stability of the local budget was calculated and considered according to the methodology proposed by L. Kostirko [8] as the sum of the indicators used in the cluster analysis. The values of the integral indicator of the financial stability of the local budget of the regions are displayed on a multidimensional diagram built using a neural network (Fig. 6).

The result illustrated in the multivariate diagram refines the results of the cluster analysis. The highest value of the indicator (4.74) can be traced in the Dnipropetrovsk region, which confirms the correctness of assigning this region to the cluster. This region in this study is the standard – the region with the largest number of coefficients that have a value corresponding to the standard. The value of the integral indicator of the financial stability of the local budget of other regions mainly corresponds to their correct assignment to the cluster.

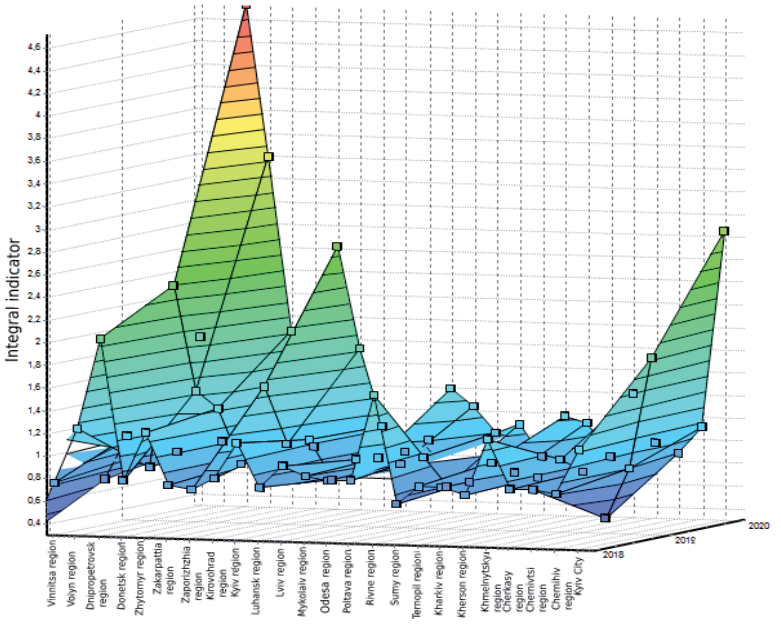

Fig. 6. Multidimensional neural network diagram

Conclusions. It can be concluded that both methods allow efficient clustering of data in a multidimensional space of sample elements in the mode of manual selection of the number of clusters. The results of clustering obtained by different methods are consistent with each other and, with complex application, allow the analyst to classify the elements of the sample with maximum likelihood and minimum error.

The regions of Ukraine can be grouped according to the financial stability of the local budget into three groups: regions with high financial stability, regions with medium financial stability and regions with low financial stability. Summing up the study, it can be argued that the system that can provide information on the performance of the financial activities of local authorities is a comprehensive analysis of the financial stability of local budgets, which gives an idea of the balance of their total income and expenses, independence from the state budget and the effectiveness of regional budgetary policy. The correct interpretation of the results obtained through a comprehensive analysis of financial stability in relation to the local budget allows not only to analyze the obtained values, but to compare them with the standard and/or conduct a comparative analysis with respect to other regions, identify the influence of factors on the change in the integral indicator, give a forecast estimate for the future and justify the chosen strategy for strengthening competitive immunity for a particular region.

The suggested methodological approach is the basis for assessing the budget policy and financial stability of the region as an object of managerial influence of competitive immunity.

Depending on the results obtained, it is possible to determine ways to improve the financial condition with a projection on strengthening the competitive immunity of the region for a larger number of regions classified as having medium or low financial stability in such areas as strengthening the revenue base of local budgets; improvement of the system for the use of local budget funds and the methodology for calculating expenditure needs; introduction of the program-target method of budget planning; determination of indicators of the effectiveness of budgetary policy at the local level.

Based on this study, it can be concluded that the Kohonen map and *k*-means clustering with the help of the Deductor business analytical platform can be used to cluster Ukrainian regions in terms of financial stability. For the more accurate results, it is recommended to review the coefficients used and to consider the possibility of introducing other coefficients that illustrate the financial side of local budgets. Such measures can lead to a more accurate distribution of regions into groups, and possible application of other clustering algorithm that will affect the final number of clusters. The implementation of the chosen strategy for the formation of competitive immunity can ensure the competitive coexistence of regions and institutionalize industrial partnership. This study and the results obtained can be considered as one of the key tools in the development of a strategy for the formation of a competitive immunity model for a particular region or group of regions.

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USING CLUSTER ANALYSIS TO ASSESS FINANCIAL STABILITY AS AN OBJECT OF MANAGERIAL IMPACT OF REGIONAL COMPETITIVE IMMUNITY

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The relevance of considering and analyzing financial stability and competitive immunity at the meso-level in modern conditions is increasing due to changes in the state of both the economic and social spheres. It was found that the "competitive immunity of the territory" reflects a number of new characteristics of modern territorial-regional-interregional competition in the global economy, which distinguishes it from the concept of economic security both at the macro and meso levels. The paper considers the category of "competitive immunity of the region", which implies the possibility of survival of the peripheral territories of the regions of Ukraine and maintaining their high level of

competitiveness. In accordance with the accepted concept of competitive immunity, three problem-area blocks were identified: information-digital approach; information and digital technologies; cost and reputation management, which include objects of managerial influence necessary to evaluate the transition of competitive immunity to sustainable functioning. The main aspect in the study of the financial stability of the local regional budgets as an integral part of the competitive immunity of the region was the search for criteria and the development of a methodology for evaluating efficiency. The following performance indicators of local budgets were used: budget revenues; budget spending; intergovernmental transfers from the state budget; tax revenues; the amount of equalization subsidies; non-tax revenues; average population. An applied study of the methodology for assessing the financial sustainability of the budget as an object of managerial influence at the local level was carried out on the example of selected indicators of local budgets of all regions of Ukraine for 2018-2020. The calculation of the selected indicators was made on the basis of statistical data on the local budgets implementation, reports and decisions of regional councils on the regional budget. The distribution of the initial data set into clusters was analyzed with help of the Deductor business analytical platform, using the *k*-means clustering algorithm and Kohonen maps.

Based on the results of the k-means algorithm, it was found that it is advisable to divide the sample for classifying regions into three groups. To compare and evaluate the effectiveness of the results obtained, as well as to supplement the analysis of the financial stability of the regions of Ukraine, Kohonen maps were used using the Deductor business analytical platform.

It was revealed that both methods allow efficient clustering of data in a multidimensional space. The results of clustering obtained by different methods are consistent with each other and, when applied in a complex manner, make it possible to classify the elements of the sample with maximum likelihood and minimum error.

The regions of Ukraine were grouped according to the financial stability of the local budget into three groups: regions with high financial stability, regions with medium financial stability and regions with low financial stability. The correct interpretation of the results obtained through a comprehensive analysis of financial stability in relation to the local budget using clustering or using neural networks allows not only to analyze the obtained values, but to compare them with the standard and conduct a comparative analysis relative to other regions, identify the influence of factors on the change in the integral indicator, give a predictive assessment for the future and justify the chosen strategy for strengthening competitive immunity for a particular region.

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