DOI: https://doi.org/10.30525/2256-0742/2022-8-3-154-165

METHODOLOGICAL APPROACH TO ASSESSING THE LEVEL OF DEVELOPMENT OF THE ECONOMIC SPACE OF THE REGIONS

Andrii Polishchuk[1], Tetiana Kotenko[2], Larysa Chepurda[3]

Abstract. *The purpose* of the article is to summarize and present the differences between the regions of Ukraine on the level of development of the regional economic space from 2010 to 2020. The clustering of the regions is performed on the basis of the author's methodical approach to assessing the level of development of the economic space of the regions. *Methodology*. The methodological approach consists of five consecutive stages of assessing the state of the regional economic space on the basis of official statistical data. The k-means algorithm is used to cluster the regions. The implementation of the proposed methodological approach is carried out on the basis of statistical data of the regions of Ukraine for the period 2010–2020. Comparison of the array of statistical data for the period 2010–2020 for the regions of Ukraine is carried out by regions and territories for which statistical data are available. Due to the Russian invasion in 2014, there is no statistical information about the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk regions. The results of the study showed that the regions of Ukraine are divided into six separate clusters, depending on the level of development of the regional economic space, in particular, the intensity of processes in the economic space. Most regions of Ukraine change the cluster only once during the period 2010–2020. At the same time, for example, Donetsk region changed its position in the clusters six times during this period. Regions of Ukraine in 2010–2014 formed three clusters with more than three regions, then three years later there were two clusters with more than 5 regions, indicating a redistribution of regions between clusters. *Practical implications*. The division of regions into clusters allows to unify regional development policy in the context of regions with similar characteristics and at the same time does not imply the use of a single template for the development of all regions. The grouping of regions by groups of indicators allows to distinguish stable entities (such as Lviv, Odessa and Kharkiv regions), slowly changing regions (with processes of development or regression) and unstable regions (such as Donetsk). For each group it is necessary to develop a separate regional policy, depending on the characteristics of the cluster. The implementation of the developed methodology will improve the classification of Ukrainian regions by groups of indicators of regional economic space development for further improvement and unification of regional development policy. *Value/originality*. The proposed methodology provides an assessment on the basis of 67 indicators characterizing the level of development of the regional economic space and forming six groups of indicators, determining for the economic space intensity of economic processes; transparency; intensity of demographic processes; labor market functioning; business diversification; ecology and infrastructure condition.

Key words: economic space, region, regional economy, cluster analysis, regional cluster, strategic management.

JEL Classification: A10, R12, R58

[1] Cherkasy State Technological University, Ukraine;
Cherkasy City Council, Ukraine *(corresponding author)*
E-mail: andrew.pol85@gmail.com
ORCID: https://orcid.org/0000-0001-8984-4098
ResearcherID: AAA-3356-2021
[2] Cherkasy State Polytechnic University, Ukraine
E-mail: kntu.inintex@gmail.com
ORCID: https://orcid.org/0000-0003-2037-7510
[3] Cherkasy State Technological University, Ukraine
E-mail: licorn1963@gmail.com
ORCID: https://orcid.org/0000-0002-8941-9427

1. Introduction

Inter- and intra-regional contrasts are a significant obstacle to the formation and implementation of effective state and regional management decisions and plans. Differentiation is especially dangerous when economic inequality between regions and local territories within a region is exacerbated by political, religious, cultural, ethnic and other differences (Kasser, 2008). Growing regional inequality, as well as the growing number of depressed territories and their financial dependence lead to social and economic instability in society and limit the possibilities of quality regional governance. All this, in the case of the worst scenarios, can lead to a significant deterioration of the socio-economic condition of the regions, their economic space, a decrease in regional competitiveness, deterioration of the quality of life and impoverishment of the population (Olsen, Osmundsen, 2003). A balanced regional policy that provides a consensus between economic efficiency and social justice is a means of addressing regional inequalities.

Thus, strategic management and planning of territorial development is one of the most important activities of regional top management. Formation of the strategy of spatial development of regions, first of all, requires a retrospective assessment of the effectiveness of their functioning, determining the similarity of management objects (at the regional and local levels) in terms of volume, dynamics and trends of socio-economic processes, etc. In the future it allows to unify management processes at the regional level and to develop unified solutions and approaches for strategic and tactical work within individual clusters (or groups) of territories. This, in turn, provides the most appropriate and efficient use of the potential of spatial resources, ensuring their competitiveness, and to achieve positive dynamics in regional development as a result of the implementation of strategies.

2. The problem of assessing the level of the economic space development

At present, given the negative impact of the COVID-19 pandemic on the level and dynamics of socio-economic development of countries and regions, governments are facing unprecedented new challenges to find new ways, tools and mechanisms of post-pandemic economic recovery. Specific regional conditions, pre-crisis problems and limited resources increase the level of complexity of this task. At the same time, these crisis conditions make it possible to understand the importance of economic space of each territory, its compliance with urgent needs, saturation, quality (in terms of resources, infrastructure, logistics solutions, openness, administrative transparency and ease of doing business, etc.) for the survival, sustainability and development of regional business and the regional economy as a whole (Schwab, Zahidi, 2020).

The formation of new ways and solutions for regional development should be based on fundamentally new forms of cooperation, transforming conflicts of interest into concerted interaction based on common features of socio-economic development and specialization of territories. This will allow the transition from inter-regional competition to constructive cooperation and the development of common, mutual mechanisms of development and strengthening the competitiveness of regions and local territories, to a model of regional economic development through improving the quality of the economic space.

3. Indices and ratings to assess the level of economic space development

International rankings and indices are used to assess and compare the level of development of the economic space of a particular country or group of countries at the global level. They are based on a methodology that integrates the latest statistical data from international organizations and surveys of business executives. Typically, such ratings are created by international organizations and consulting agencies and based on the evaluation of a large array of statistics, including those summarized and published in reports and studies of internationally recognized organizations such as the United Nations (UN), the United Nations Industrial Development Organization (UNIDO), United Nations Educational, Scientific and Cultural Organization (UNESCO), Organization for Economic Cooperation and Development (OECD), World Trade Organization (WTO), World Economic Forum (WEF), World Bank (WB), International Labor Organization (ILO), International Energy Agency (IEA), International Telecommunication Union (ITU), and others. The most famous and used by scientists, governments and businesses are the following annual indices, which are the basis for ranking the economic space of the world.

1. The Doing Business index has been calculated by the World Bank Group for 190 countries since 2002. The Doing Business project provides an objective assessment of the state of business regulation and its compliance. The first Doing Business report, published in 2003, covered five sets of indicators and 133 economies. The final study, published in 2019, covered 11 sets of indicators and 190 economies (Doing Business, 2020).

2. Global Competitiveness Report, developed by the World Economic Forum since 1979. These

aggregate indices are categorized into 12 components: Institutions; Infrastructure; ICT adoption; Macroeconomic stability; Health; Skills; Commodity market; Labor market; Financial system; Market size; Business dynamism; Innovation capabilities.

3. The Globalization Index (KOF Globalization Index), calculated since 1970 by the Swiss Institute of Economics (KOF Swiss Economic Institute). This is the aggregate index, the calculation of which is based on 3 pillars of globalization: Economic (Trade & Financial), Social Informational, Interpersonal & Cultural), and Political.

4. The Global Cities Index, calculated by A.T. Kearney since 2008. The methodology of evaluation allows measuring the economic space and its impact on the biggest cities' global development in five spheres. These include human capital, business activity, cultural experience, information exchange, and political activity. Twenty-six indicators in these five dimensions are used to rank more than 150 megacities around the world and measure how engaged they are in the global economy (Kearney Analytics, 2021).

5. Globalization Index A.T. Kearney (A.T. Kearney/ Foreign Policy Globalization Index), calculated annually since 2000 and examines the underlying international trends that reveal whether the world's leading nations are becoming more or less globally connected (Kearney Analytics, 2021). This index is based on four sub-indexes: economic integration (incl. foreign direct investment, international trade etc.); personal contact (incl. travel, telephone, and remittances); technological connectivity (incl. number of secure servers, hosts, internet users etc.); political engagement (incl. participation in organizations, treaties, and peacekeeping).

6. Readiness for the Future of Production Index, calculated since 2008 by WEF aimed at the evaluation of the global involvement of national economics and development insights about how a city can become more global. The Index is based on 59 indicators that capture pertinent concepts that are fundamental to a country's readiness for the future of production. These indicators are grouped into two large groups – Structure and Drivers of Production (World Economic Forum, 2018).

Thus, when assessing the economic space, international organizations and academic institutions primarily determine its openness and accessibility for economic activity of both internal and external economic agents of various organizational and legal forms, sizes and directions of economic activity. As a rule, along with the economic characteristics of the space, which prevail in the assessment, its political, technical, technological and social characteristics are studied.

However, despite the fact of the constant attention of developers to the relevance of the rankings methodology, nowadays challenges require a review of methodological approaches and decisions on their feasibility (World Bank, 2021). Moreover, the use of these methodological approaches is overwhelmingly impossible for comparisons at the level of the regional economy of a single state, since some of the indicators proposed in these approaches are unchangeable for individual areas within the country. A small exception to this list are countries with a federal structure. At the same time, the establishment of inter-regional differences and similarities is a task to ensure effective regional and state governance and strategic planning.

In the case of Ukraine, all these challenges were added to the full-scale invasion and war by Russia. At the state level, economic space is usually assessed by authorized bodies of governments according to legally approved methodologies and/or by consulting agencies, as well as by academic institutions according to their own developed methodologies. It is worth noting the wide range of indicators used, the large number of ratings and results, which are often not comparable due to the variety of approaches and indicators used in the assessment process. Thus, in Ukraine, the assessment of the level of socio-economic development of regions and their ranking at the state level is carried out since 2008, according to the Resolutions of the Cabinet of Ministers No. 833 dated 20.06.2007 (during 2007–2011), 650 dated 9.06.2011 (during 2012–2014); 856 dated 21.10.2015 (from 2016 to the present). The assessment is conducted in two stages: 1) analysis of the dynamics of regional indicators in the relevant areas; 2) evaluation of the rating of regions in each area and calculation of the overall rating and the corresponding ranking of regions from the 1st (best indicator value) to the 27th (worst indicator value) place. The number of indicators used for evaluation varied from 55 (2008–2011) to 81 (2012–2014) and 64 (2016–2022). Despite a significant number of indicators (up to 47%) proposed for ranking the regions over the entire period (2008–2022), they belong to different groups (7, 11 and 12 groups of indicators in 2008–2011, 2012–2014 and 2016–2022, respectively), the addition of the list of indicators and removal of certain indicators from the list does not allow a reliable comparison of regional rankings over the entire period.

Despite the high evaluation of the current methodology, today it needs to be clarified and supplemented with new indicators for qualitative full-fledged evaluation and ranking of the regions in modern conditions. New strategic priorities of development of Ukraine and its regions confirmed the relevance of the development of new approaches to assessment. That is why the development of methodological approaches to assessing the level of socio-economic development of regions, as well as

the level of development of the regional economic space requires further scientific research.

4. Methodological approach to assessing the level of economic space development and clustering of regions

A balanced policy of regional development is a prerequisite for the successful development of the country. A single approach to the formation of regional policy for all regions is not suitable, it is necessary to identify several (for example, from 3 to 7) groups of regions with similar characteristics. Only for such groups of regions the approaches to the construction of regional policy and strategies of regional development can be uniform.

In this study, the programming language Python 3.7.13, the environment (virtual machine) – Google Colaboratory was used to assess the level of development of the regional economic space. The following libraries were also used: NumPy, pandas – for calculations and data representation; sklearn – for normalization and K-Means algorithm; matplotlib – for figures; geopandas – for maps; Google Spreadsheet – for collecting and summarizing statistical data.

The proposed methodological approach consists of five stages. Stage 1 – definition of the goals and priorities of assessing the development of the regional economic space and clustering of regions; Stage 2 – formation of a set of indicators and their grouping (alternatively – selection of indicators from the proposed set and grouping of indicators under the evaluation goals and priorities).

Generalization of the existing methodological approaches, as well as the results of our research allow us to propose six main groups of indicators, formed from the most important indicators that determine the level of development of the regional economic space. In the future they will be used to assess and rank the regions, Table 1.

Three groups of indicators: the first "The main indicators of the intensity of economic processes in the economic space", the second "Indicators of the economic space transparency" and the sixth "Environmental and infrastructural indicators that determine the quality of life in the economic space" divided into two subgroups. The first subgroup consists of the intensity indicators determined due to the population of the region, and the second – is due to the area of the region. This will allow for the formation and compare regional clusters in terms of the development of their economic space according to two main criteria of intensity.

Table 2 lists fifteen indicators from the first subgroup of the first group that characterize the intensity of economic processes (at the expense of the region's population) in the economic space.

Stage 3 – collection and synthesis of statistical information. Calculation of indicators with subsequent analysis of the dynamics of indicators in the relevant areas for each region without inter-regional comparison.

Stage 4 – clustering of regions for each of the six groups of indicators by comparing the deviations of indicator values for each region from their best values for the region in the corresponding (reporting) period and the formation of appropriate clusters. The grouping of regions makes it possible to reduce regions into separate groups based on similarity of indicators, which will further simplify the procedures and mechanisms for regional policy development, its revision and improvement for regional governments.

Analysis of existing approaches to data clustering used in the methodology of economic research (Murty, 1999), (Estivill-Castro, 2002), (Frey, Dueck, 2007), (Garbade, 2018), (Panapakidis, Christoforidis, 2018), (Petkova, Ryabokon, Vdovychenko, 2019) et al. and their evaluation following the objectives and conditions of this research, argued the necessity to build a centroid model for regional clustering in the study of spatial economic processes based on the

Table 1
Regional development indicator groups

Group name	Group number	Subgroups	Group codes	Number of indicators in a group or subgroup
The main indicators of the intensity of economic processes in the economic space	1	2	11; 12	15
Indicators of the economic space transparency	2	2	21; 22	12
Basic demographic indicators of economic space	3	0	30	6
Indicators of the labour market functioning in the economic space	4	0	40	9
Indicators of entrepreneurial diversification of the economic space	5	0	50	18
Environmental and infrastructural indicators that determine the quality of life in the economic space	6	2	61; 62	7
Total	6	6		65

Source: developed by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

Table 2
Regional indicators by groups 1, sub-group 1

Indicator	Description
$I_{1.1.1}$	Gross regional product per capita, UAH
$I_{1.1.2}$	Foreign direct investment (share capital) per capita, UAH
$I_{1.1.3}$	The volume of sold products (goods, services) per capita, thousand UAH
$I_{1.1.4}$	Number of operating business entities per 1000 population
$I_{1.1.5}$	Number of enterprises per 1000 population
$I_{1.1.6}$	Number of individual entrepreneurs, per 1000 population
$I_{1.1.7}$	Household income per capita, UAH
$I_{1.1.8}$	Industrial production indices by region (up to the previous year)
$I_{1.1.9}$	Construction production indices by region (up to the previous year)
$I_{1.1.10}$	Agricultural production indices by region (up to the previous year)
$I_{1.1.11}$	Share of capital investments from the state budget
$I_{1.1.12}$	Household expenditures per capita, UAH
$I_{1.1.13}$	Capital investments per capita, thousand UAH
$I_{1.1.14}$	Financial result before tax, per capita, thousand UAH
$I_{1.1.15}$	Net profit (loss), per capita, thousand UAH

Source: developed by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

K-means methods of clustering. Also, the K-means method was chosen because of its prevalence (Panapakidis, Christoforidis, 2018), (Codecademy, 2021), the availability of libraries for its use and implementation in conventional libraries for data analysis. The sklearn library is used (Scikit, 2021).

To determine the optimal number of clusters, an index of inertia (SSE) is calculated for each year and or each group of indicators (Figure 1). The optimal number of clusters will be one in which the SSE will no longer decrease significantly for all years and groups of indicators Garbade M. J (2018).

Since the K-Means algorithm assumes initialization of cluster centers with random or defined values, it is proposed to use random values for the first year and to use cluster centers of the previous year for all subsequent years. This will distribute regions into clusters that are as close to the clusters of the previous year as possible. The correspondence of the region to a particular cluster can then be investigated in dynamics. Using the K-Means clustering algorithm, which aims to find clusters among the indicators, then extend it to analyze indicators that change over time.

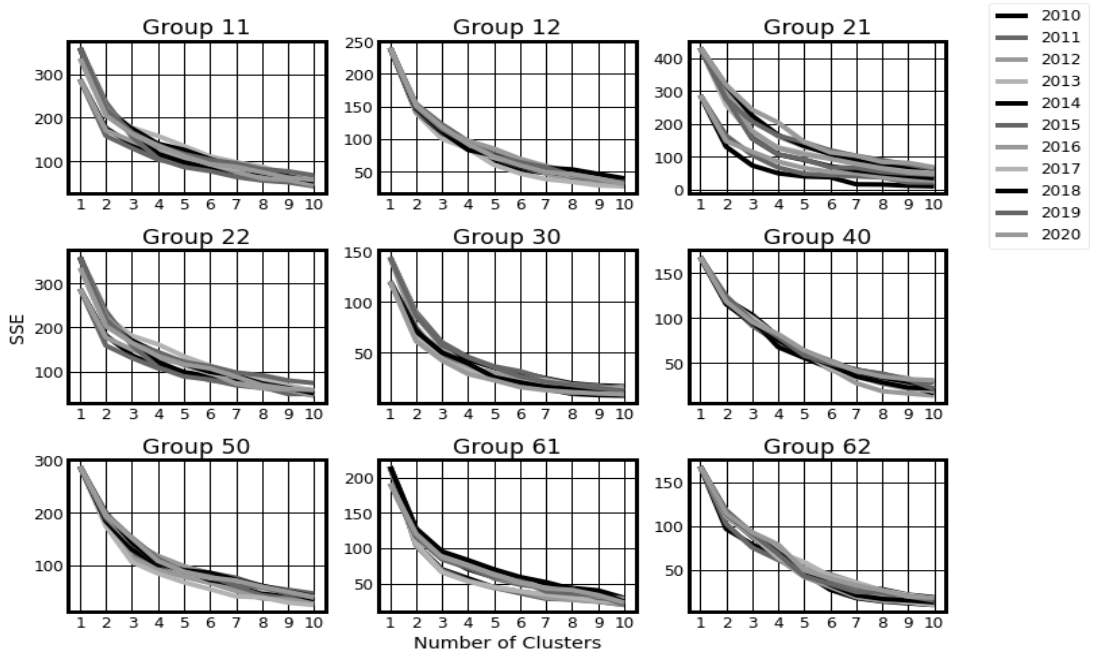

Figure 1. Calculation of the number of clusters by year

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

Sometimes 5-7 clusters are already considered sufficient, while in other cases (like group 21) it is 6-7 clusters, Figure 1. The SSE behavior is similar for 6 clusters, so we will consider this number below. The indices of the clusters (from 1 to 6) depended on the distance of the indicators of the regions in the cluster from its centroid, in ascending order, where 1 cluster is the smallest distance, 6 cluster is the largest.

5. Findings

The conclusions in this article demonstrate the results of the first group of indicators – indicators of intensity of processes in the economic space, subgroup 1 (according to the accepted classification – group 11, see Tables 2, 3). The implementation of the proposed methodological approach was carried out on the basis of statistical data of the regions of Ukraine for the period 2010–2020 (State Statistics Service of Ukraine, 2010–2020). The results are presented in Table 3. Comparison of the array of statistical data for 2010–2020 by regions of Ukraine is carried out by regions and territories for which statistical data are available. Due to the Russian invasion in 2014, there is no statistical information on the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk regions.

Most regions of Ukraine change the cluster only once during the period 2010–2020. For example, the Odessa, Lviv, and Kharkiv regions consistently form one – third cluster. The exception is the change of cluster 6 for the Kharkiv region in 2011 and the Odessa region in 2010, see Table 4. At the same time, for example, Donetsk region changed its position in clusters six times during 2010–2020. In addition, for clarity and clarity, the results of clustering can be displayed on a map. Thus, Figure 2 shows regional clusters for group 11 for 2010–2020.

Kyiv and Dnipro regions in 2020 were included in one, the first cluster, Figure 2. Poltava region in 2020 differed from the others and was in a separate cluster 2. And Lviv, Odessa and Kharkiv regions were consistently included in one cluster № 3 (see Table 4, Figure 2). The fourth and fifth clusters are the largest in terms of the number of regions. The fourth cluster includes Volhynia, Khmelnytskyi, Vinnytsia, Cherkasy, Chernihiv, and Sumy regions, and the fifth cluster includes Zakarpattia, Ivano-Frankivsk, Chernivtsi, Ternopil, Rivne, Donetsk, and Luhansk regions. The sixth cluster includes Zhytomyr, Kropyvnytskyi, Mykolaiv, Kherson, and Zaporizhzhia regions. Similar

Table 3
Ukraine's region in clusters by years

	Region code	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Vinnytsia	UA.VI	5	5	5	4	4	4	5	4	4	4	4
Volhynia	UA.VO	1	5	4	5	4	5	4	4	4	4	4
Dnipro	UA.DP	2	2	2	2	1	1	1	1	1	1	1
Donetsk	UA.DT	6	6	6	1	3	2	5	5	4	5	5
Zhytomyr	UA.ZT	4	1	1	4	5	4	5	5	4	5	6
Zakarpattia	UA.ZK	1	4	4	5	5	4	4	5	5	5	5
Zaporizhzhia	UA.ZP	6	5	3	3	6	6	6	6	6	6	6
Ivano-Frankivsk	UA.IF	4	1	4	4	4	5	4	5	5	5	5
Kyiv	UA.KV	6	6	6	6	1	1	1	1	1	1	1
Kropyvnytskyi	UA.KH	5	5	5	4	4	4	4	4	5	4	6
Luhansk	UA.LH	3	1	3	3	2	2	2	2	2	2	5
Lviv	UA.LV	3	3	3	3	3	3	3	3	3	3	3
Mykolaiv	UA.MY	5	5	5	4	4	5	5	4	5	4	6
Odessa	UA.OD	6	3	3	3	3	3	3	3	3	3	3
Poltava	UA.PL	6	6	6	6	6	6	6	6	6	6	2
Rivne	UA.RV	5	4	4	4	5	4	4	5	4	5	5
Sumy	UA.SM	3	4	4	4	4	4	4	4	5	5	4
Ternopil	UA.TP	5	4	4	5	5	4	4	5	5	4	5
Kharkiv	UA.KK	3	6	3	3	3	3	3	3	3	3	3
Kherson	UA.KS	4	4	5	4	4	4	4	4	5	4	6
Khmelnytskyi	UA.KM	4	5	4	4	4	4	4	5	4	5	4
Cherkasy	UA.CK	4	4	4	4	4	4	4	4	4	6	4
Chernivtsi	UA.CV	5	4	4	4	4	4	4	5	5	5	5
Chernihiv	UA.CH	3	4	4	5	5	4	4	5	4	4	4

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

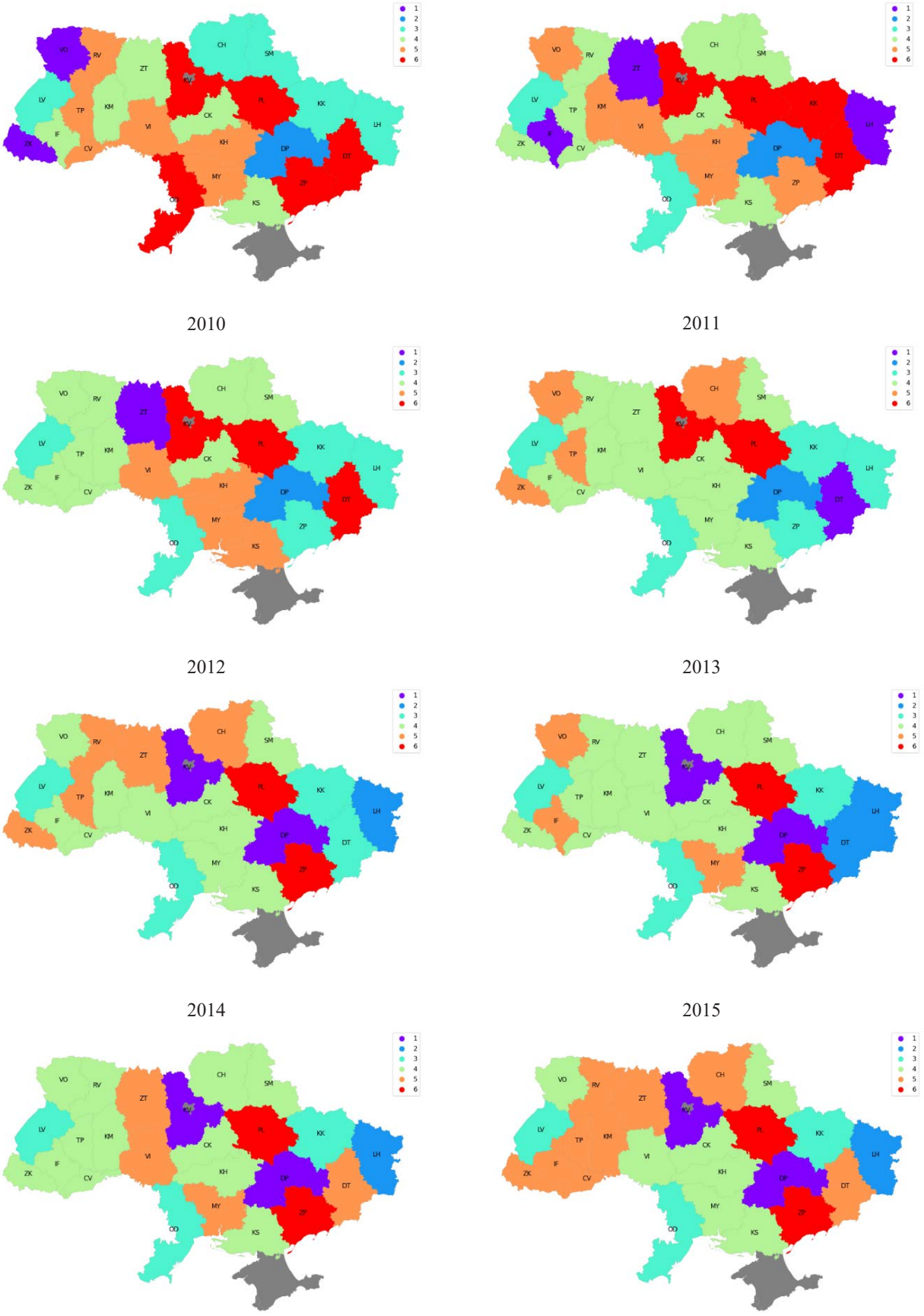

Figure 2. Clustering of regions of Ukraine by the intensity of economic processes in the economic space (group 1, 1 subgroup), 2010–2020

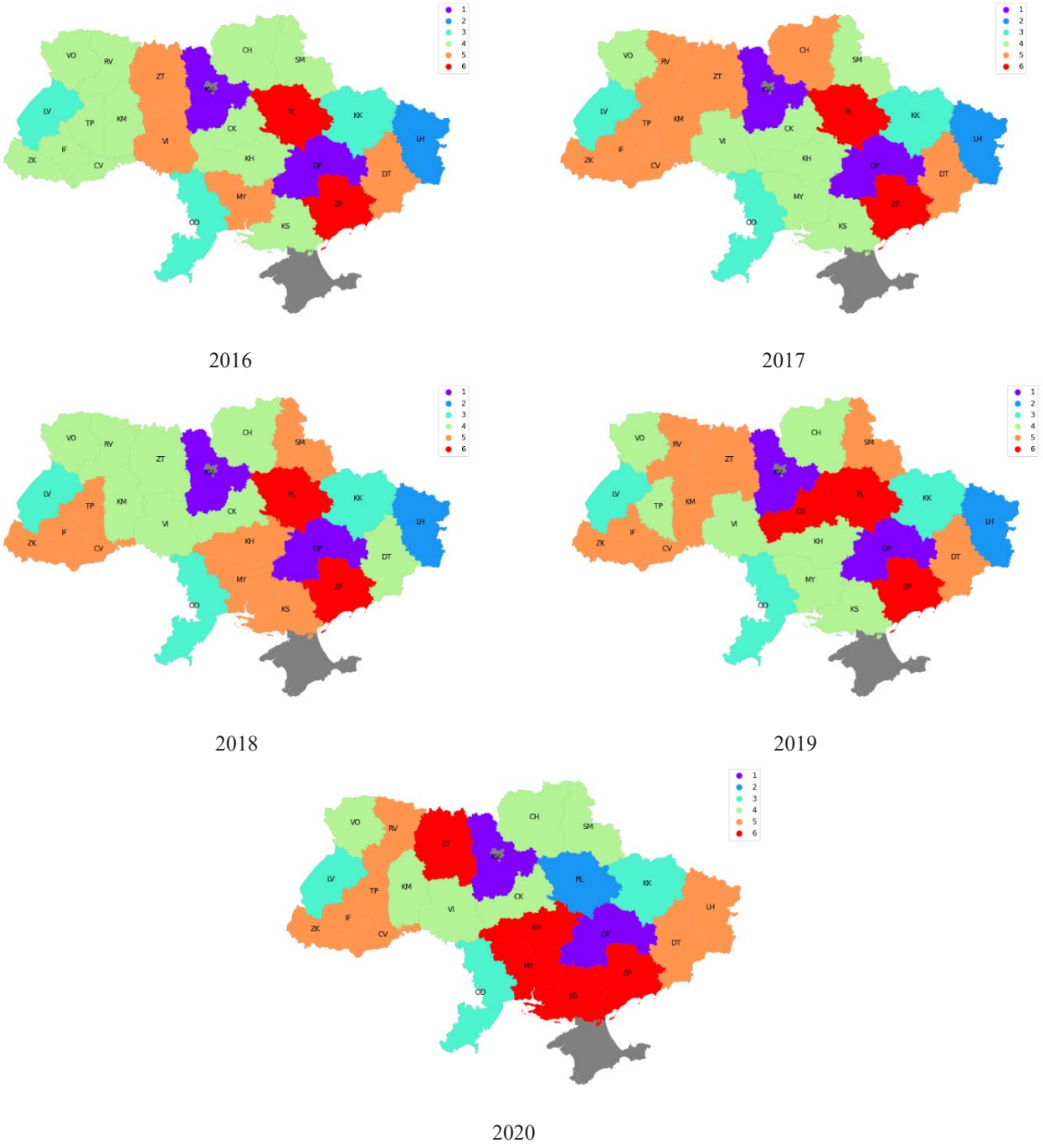

Figure 2. Clustering of regions of Ukraine by the intensity of economic processes in the economic space (group 1, 1 subgroup), 2010–2020

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

trends in the number of clusters by region have been observed in previous periods, Table 4.

Regions of Ukraine in 2010–2014 formed three clusters with more than three regions, then three years later there were two clusters with more than 5 regions, indicating a redistribution of regions between clusters, Table 4. The structural shifts in the distribution of regions between clusters are shown in Figure 3.

The next step involved analyzing the differences between clusters, which requires analyzing the differences between the centers of the clusters (centroids), which are based on the normalized values of the indicators, and therefore can be used for visualization (Figure 4).

Accordingly, cluster indicators and the clusters themselves change over time, so the region may move

Table 4

The number of Ukraine's regions in clusters by years

Cluster	Regions per cluster										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	2	3	1	1	2	2	2	2	2	2	2
2	1	1	1	1	1	2	1	1	1	1	1
3	5	2	5	5	4	3	3	3	3	3	3
4	5	8	10	11	10	12	12	7	8	7	6
5	6	6	4	4	5	3	4	9	8	8	7
6	5	4	3	2	2	2	2	2	2	3	5

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

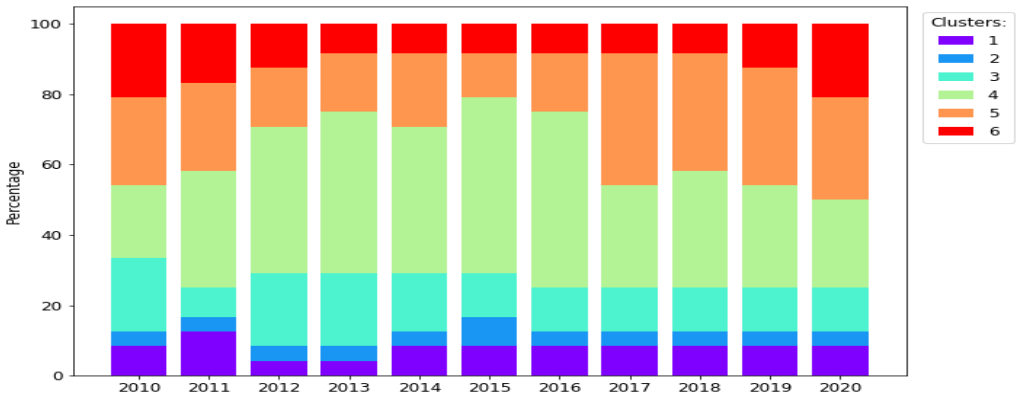

Figure 3. Structure of clusters of the regional economic space of Ukraine depending on the intensity of economic processes, 2010–2020

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

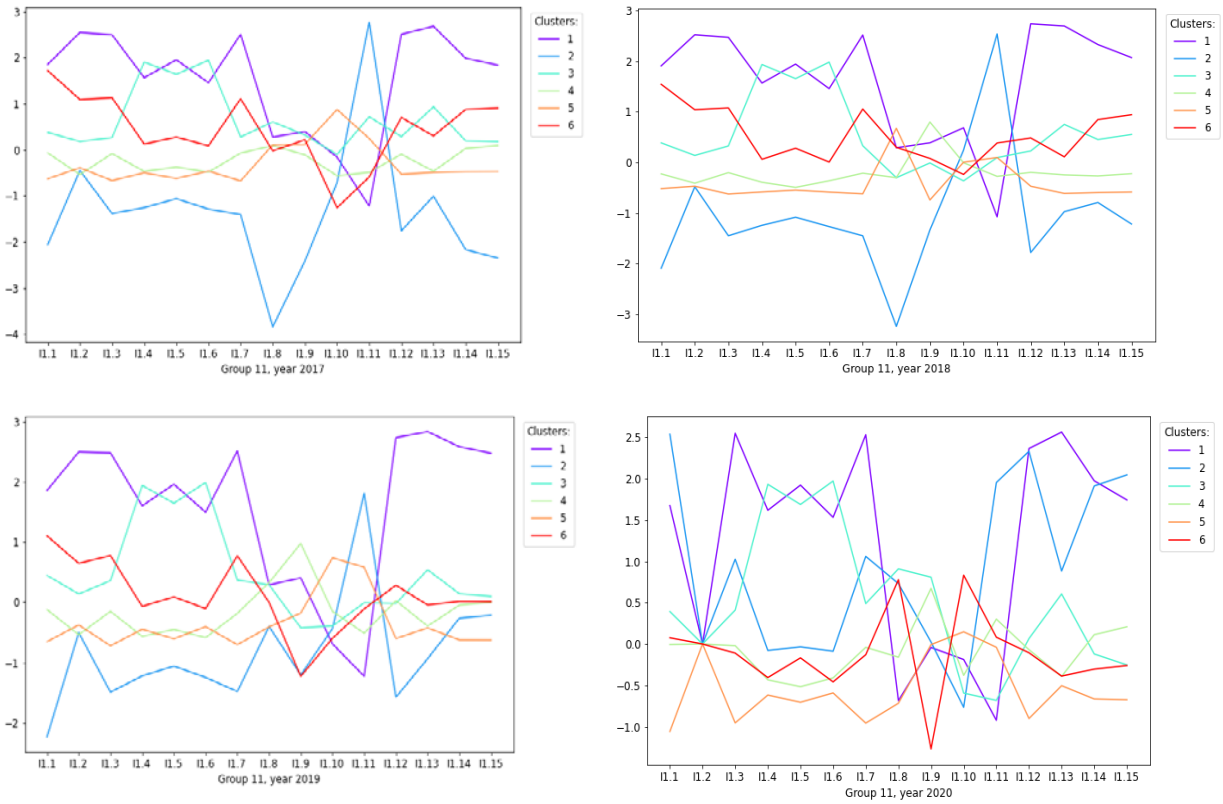

Figure 4. Differences between cluster's centroids, 2017–2020

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

to another cluster because of deep in the country as a whole, rather than in a single region. Some regions form permanent clusters (Lviv, Odessa, Kharkiv), others migrate from one cluster to another (Figure 2, Figure 4, Table 3). Usually this does not happen quickly. However, as a result of significant upheavals, it can happen, as in the case of the Donetsk region. But this is the exception rather than the rule. Moreover, due to significant changes in the socio-economic state of the regions and their economic space, not only clusters change, but also signs of the region's belonging to one or another cluster. Regions migrate from one cluster to another infrequently, unless some serious shocks occur. Thus, the grouping of regions according to certain characteristics allows to determine the regional policy for each group of regions, as well as to compare the "profile" of the cluster of depressed regions (according to the six groups of indicators of the methodology) allows to determine which aspect should be developed.

Further, a separate indicator rank was used to rank the regions according to the level of economic space development from the highest to the lowest level. It can be determined annually separately by the arithmetic average value of the cluster regions' target indicator. The regional cluster with the highest level of development has the highest value of the target indicator (rank 1), Table 5.

The results show the leaders of the rating by the level of development of the regional economic space (in cluster 11 – the intensity of economic processes in the economic space). Dnipro region was the leader of the rating during 2010–2019 (cluster 2, during 2010–2013; cluster 1 during 2014–2019). Kyiv region was among the leaders in 2014–2019 (cluster 1). However, in 2020 the situation changed, and the second cluster with one participant – Poltava region – took the lead.

The final, fifth stage of assessing the level of development of the regional economic space involves the creation of unified clusters and regions' in the main areas (groups of indicators) that characterize the level of development of the regional economic space.

6. Conclusions

The division of regions into clusters allows the unification of regional development policy in the context of regions with similar characteristics and, at the same time, does not imply the use of a single template for the development of all regions. Grouping regions by groups of indicators allows to identify stable entities (such as Lviv, Odessa and Kharkiv regions), slowly changing regions (with processes of development or regression) and unstable regions (such as Donetsk). A separate regional policy should

Table 5

Clusters' ranking due to the level of regional economic space development

2010			2011			2012			2013		
cluster	centroid	rank	cluster	centroid	rank	cluster	centroid	rank	cluster	centroid	rank
1	13.1	6	1	20.56667	4	1	19.6	6	1	37.8	3
2	34.7	1	2	42,1	1	2	44,7	1	2	46,3	1
3	18,18	3	3	23,1	3	3	27,64	3	3	28,02	4
4	14,92	4	4	17,1	6	4	19,8	5	4	22,08	5
5	14,42	5	5	20.5	5	5	21,28	4	5	19.05	6
6	26.2	2	6	33.5	2	6	39.27	2	6	40	2
2014			2015			2016			2017		
cluster	centroid	rank	cluster	centroid	rank	cluster	centroid	rank	cluster	centroid	rank
1	49.9	1	1	63	1	1	74.8	1	1	93.55	1
2	14.1	6	2	18.85	6	2	14.3	6	2	13.9	6
3	30.7 8	3	3	41,6	3	3	50,9	3	3	63,47	3
4	25,77	4	4	31,77	5	4	36,43	5	4	54,39	4
5	22,88	5	5	35,03	4	5	41,88	4	5	42,98	5
6	42,65	2	6	58.5	2	6	70.4	2	6	90.75	2
2018			2019			2020					
cluster	centroid	rank	cluster	centroid	rank	cluster	centroid	rank			
1	113.65	1	1	122.75	1	1	114.1	2			
2	16,3	6	2	18,7	6	2	135,1	1			
3	76,6	3	3	86,83	3	3	82,93	3			
4	61,67	4	4	72,4	4	4	73,25	5			
5	54,61	5	5	58,89	5	5	47.6 6	6			
6	104.8	2	6	103.53	2	6	75.22	4			

Source: calculated by the author according to the data of (State Statistics Service of Ukraine, 2010–2020)

be developed for each group, depending on the peculiarities of the cluster.

The implementation of the developed methodology will improve the classification of Ukrainian regions by groups of indicators of regional economic space for further improvement and unification of regional development policy. The proposed methodology provides, unlike the existing ones, an assessment based on 67 indicators that characterize the level of development of regional economic space and form six integral indicators that determine the intensity of economic processes; transparency of economic space; intensity of demographic processes in the economic space; functioning of the labor market in the economic space; entrepreneurial diversification of the economic space; ecological condition and quality of infrastructure of the economic space. In addition, unlike existing approaches, the clustering of regions in the method of regional economic space development is carried out by an improved k-means method, which allows to analyze the dynamics of the region's transition from one cluster to another and allows to determine the needs for improving regional development policy.

References:

Business Enabling Environment (2021). World Bank. Available at: https://www.worldbank.org/en/programs/business-enabling-environment/doing-business-legacy

Clustering (2021). Scikit. Available at: https://scikit-learn.org/stable/modules/clustering.html#k-means

Clustering: K-Means (2020). Available at: https://www.codecademy.com/learn/machine-learning/modules/dspath-clustering/cheatsheet

Doing Business 2020 (2020). Economy Profile Ukraine. World Bank Group. Available at: https://www.doingbusiness.org/content/dam/doingBusiness/country/u/ukraine/UKR.pdf

Estivill-Castro, V. (2002). Why so many clustering algorithms: a position paper. *ACM SIGKDD Explorations Newsletter*, vol. 4, issue 1. June, pp. 65–75. DOI: https://doi.org/10.1145/568574.568575

European Commission (2015). The Role of Science, Technology and Innovation Policies to Foster the Implementation of the Sustainable Development Goals (SDGs). Report of the Expert Group "Follow-up to Rio+20, notably the SDGs". Available at: http://ec.europa.eu/newsroom/horizon2020/document.cfm?doc_id=12065

Frey, B. J., & Dueck, D. (2007). Clustering by passing messages between data points. *Science*, vol. 315 (5814), pp. 972–976.

Garbade, M. J (2018). Understanding K-means Clustering in Machine Learning. *Towards data science.* Sep 13. Available at: https://towardsdatascience.com/understanding-k-means-clustering-in-machine-learning-6a6e67336aa1

Kasser, M. (2008). The Economics of Transition: From Socialist Economy to Market Economy. London: Macmillan Press, 295 p.

Kearney Analytics. Available at: https://www.kearney.com/https://www.kearney.com/analytics

Murty, J. (1999). Data clustering: a review. *ACM Comput. Surv*., vol. 31(3).

Olsen, T. E., & Osmundsen, P. (2003). Spillovers and international competition for investments. *Journal of International Economics*, vol. 59, issue 1, pp. 211–238.

Panapakidis, I. P., & Christoforidis, G. C. (2018). Optimal selection of clustering algorithm via Multi-Criteria Decision Analysis (MCDA) for load profiling applications. *Appl. Sci*., 8(2), 237. DOI: https://doi.org/10.3390/app8020237

Petkova, L., Ryabokon, M., & Vdovychenko, Y. (2019). Modern systems for assessing the informatization of countries in the context of global sustainable development. *Baltic Journal of Economic Studies*, vol. 5, no. 2, pp. 158–170. DOI: https://doi.org/10.30525/2256-0742/2019-5-2-158-170

Robinson, J. (2002). Global and World Cities: View from off the Map. *International Journal of Urban and Regional Research*, vol. 26, no. 3, pp. 531–554.

Python (2021). Available at: https://www.python.org/

Schwab, K. (2019). The Global Competitiveness Report 2019. World Economic Forum. Available at: http://www.weforum.reports/global-competitiveness-report-2019

Schwab, K., & Zahidi, S. (2020). The Global Competitiveness Report. Special edition 2020. How Countries are Performing on the Road to Recovery. World Economic Forum. Available at: https://www.weforum.org/reports/the-global-competitiveness-report-2020

Statistical publication "Regions of Ukraine – 2011". State Statistics Service of Ukraine. Kyiv, 2011. Part I. 358 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2011". State Statistics Service of Ukraine. Kyiv, 2011. Part II. 788 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2012". State Statistics Service of Ukraine. Kyiv, 2012. Part I. 310 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2012". State Statistics Service of Ukraine. Kyiv, 2012. Part II. 801 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2013". State Statistics Service of Ukraine. Kyiv, 2013. Part I. 322 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2013". State Statistics Service of Ukraine. Kyiv, 2013. Part II. 783 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2014". State Statistics Service of Ukraine. Kyiv, 2014. Part I. 299 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2014". State Statistics Service of Ukraine. Kyiv, 2014. Part II. 733 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2015". State Statistics Service of Ukraine. Kyiv, 2015. Part I. 305 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2015". State Statistics Service of Ukraine. Kyiv, 2015. Part II. 681 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2017". State Statistics Service of Ukraine. Kyiv, 2017. Part I. 323 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2017". State Statistics Service of Ukraine. Kyiv, 2017. Part II. 687 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2018". State Statistics Service of Ukraine. Kyiv, 2018. Part I. 315 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2018". State Statistics Service of Ukraine. Kyiv, 2018. Part II. 682 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2019". State Statistics Service of Ukraine. Kyiv, 2019. Part I. 309 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2019". State Statistics Service of Ukraine. Kyiv, 2019. Part II. 657 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2020". State Statistics Service of Ukraine. Kyiv, 2020. Part I. 276 p. Available at: http://www.ukrstat.gov.ua/

Statistical publication "Regions of Ukraine – 2020". State Statistics Service of Ukraine. Kyiv, 2020. Part II. 675 p. Available at: http://www.ukrstat.gov.ua/

World Bank, International Bank for Reconstruction and Development (2015). Ukraine. Urbanization Review, World Bank Report №: ACS15060, 218 p. Available at: http://city2030.org.ua/sites/default/files/documents/Urban%20Review%20UA_0.pdf

World Economic Forum (2018). The Readiness for the Future of Production Report 2018. World Economic Forum's System Initiative on Shaping the Future of Production. Available at: http://wef.ch/fopreadiness18

Received on: 20th of July, 2022
Accepted on: 18th of August, 2022
Published on: 30th of September, 2022