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Clusterization in Tourism Development Level's Assessment of Regions: Example of Ukraine

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Abstract
Tourism development is uneven, which is related to the level of socio-economic development of territories, peculiarities of historical and cultural processes, resource provision, etc., which determines the need to study the structure of the tourist market based on spatial polarization based on statistical methods. The study aims to identify disparities in tourism development in Ukraine's regions and to group them according to indicators that characterize tourism's development level. To solve the problem, the authors used a modified cluster analysis method. The article presents the author's approach, which, unlike the existing ones, allows taking into account clarifying weighting factors and corrective penalty functions for each indicator to minimize probabilistic influences when determining the distance between objects. The uneven development of the tourism sector in the regions of Ukraine was revealed. As a result, six clusters were distinguished based on indicators of tourism development in the regions of Ukraine as of 2020, and the peculiarities within each cluster were found. State authorities can use the research results to ensure the comprehensive development of territories by forming effective regional tourism strategies and promoting the development of the most promising tourism destinations and products.

Key Words: tourism, cluster analysis, weighting factors, penalty function, standardization of indicators

JEL Classification: C38; R10; Z32

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1. Introduction

Tourism plays a significant role in the economy of many countries and can be particularly important in remote/peripheral regions such as coastal, mountainous, or outermost ones. Infrastructure created for tourism contributes to local and regional development, and jobs created or maintained can help counteract industrial or rural decline (Eurostat, 2021). Tourist destination regions are crucial for the tourism system, as tourist destinations and their image attract tourists, motivating visits and activating an entire tourism system (Prokopenko et al., 2019; Haviernikova et al., 2017).

Statistical data confirm an important role in tourism development. Before the pandemic, tourism and travel accounted for 1 in 4 out of all new jobs created in the world (10.3% of all jobs) and 10.3% of global GDP ($9.6 trillion). In 2019, international visitor spending amounted to $1.8 trillion (6.8% of total exports). After losing nearly $4.9 trillion in 2020 (-50.4% decline), travel and tourism's contribution to GDP increased by $1 trillion (+21.7% growth) in 2021. In 2019 the travel and tourism sector accounted for 10.3% of world GDP; in 2020, its share decreased to 5.3% due to permanent mobility restrictions, while in 2021 increased to 6.1%. In 2021, 18.2 million jobs were restored, which is 6.7% more than in 2020 (WTTC, 2022).

According to the UNWTO, given the importance of the tourism and travel sector as a major export category (before the pandemic, tourism was the third largest in the world after fuel and chemicals), and recognizing its role as a source of employment and economic development, recovery of the sector is expected to contribute to the growth of each region of the world (UNWTO, 2022).

Along with this, the issue of disparities in socio-economic and natural-resource development of tourism services markets of many countries, in particular Ukraine, remains unaddressed. Development of certain types of tourism also requires various infrastructural support (provision of automobile roads, hotels, and catering establishments, support of family businesses etc.). This creates a need to promote the development of certain tourism types (e.g., recreational sea tourism has developed in the south of Ukraine due to its proximity to the Black Sea, while in the western regions of Ukraine, favorable conditions for mountain or rural green tourism are due to the mountainous Carpathian terrain). It is an indisputable fact that Ukraine is quite differentiated in terms of tourism development by region. This is facilitated by the following factors (Shpak et al., 2021b; Kozyk et al., 2021; Lewandowska et al., 2021; Civelek et al., 2019; Ivancsóné et al., 2018): heterogeneity of natural and climatic conditions; regional socio-economic development; level of development of adjacent industries; state of the infrastructure, especially transport, information, and communication; the geographical location of regions; historical and cultural heritage; traditions and mentality of people; ecological state of the environment, etc.

Despite the predominance of species-specific specialization of tourism development in the regions of Ukraine (e.g., Odesa region – sea tourism, Ivano-Frankivsk region – mountain tourism), regional features of its development, caused by the influence of the above factors, remains poorly researched. Disparities in regional tourism development have a negative impact on the state as a whole and should be studied to determine state and regional policy that would take into account the specified features (Khandohina, 2020). That is why there is a need to group regions of Ukraine into homogeneous groups with similar tourism features in order to further evaluate and improve their development strategy.

The main feature of the Ukrainian tourism market is its uneven development. Dispersion of indicators values of tourism companies functioning in the regions, existing asymmetry of volumes of outbound and inbound tourism, and insufficient market infrastructure development determine the expediency of using cluster analysis at a preliminary research stage (Druzhynina, 2017).

For the division of the regions according to their level of tourism development, we suggest using a method of multidimensional statistical analysis – the method of cluster analysis, which allows taking into account a fairly significant number of criteria at the same time. This method enables singling out homogeneous groups (clusters) based on certain criteria.

Considering the above considerations, the purpose of this study is to identify disparities in the development of tourism in the regions of Ukraine and group them according to indicators that characterize the level of the tourism sector development. Based on the relevance of the topic and problems raised in the article, the emphasis is on answers to the following questions:

RQ1: Are there differences in the development of tourism in the regions of Ukraine?

RQ2: What groups of regions (clusters) of Ukraine can be distinguished by the level of tourism development?

To solve the set goals, the authors use a modified method of cluster analysis. The proposed approach, unlike the existing ones, allows to take into account clarifying weighting factors and corrective penalty functions for each indicator to minimize probabilistic effects when determining distances between objects. The results of the research will allow for finding out specifics of tourism development within each cluster.

The article is structured as follows. First, theoretical foundations of review of scientific sources on the research issues are presented. Secondly, the information base and research methodology are presented. The next part of the article highlights the results of grouping of the Ukrainian regions according to tourism development indicators. Finally, the study's discussion, conclusions, and limitations are presented.

2. Literature review

Analysis of the territorial unevenness of the tourism market development

Development of tourism is uneven, which is related to the level of socio-economic development, peculiarities of historical and cultural processes, natural and resource provision of a territory where travel companies and tour operator interact etc. (Akbulaev et al., 2020; Vasanicova et al., 2021). Thus, an imbalance is created for the constant formation and realization of economic interests at all levels of the economic system – from micro (Chang et al., 2022; Zhu et al., 2022) to macro (Ferreira et al., 2020) and mega levels (Ivancsóné et al., 2018).

Chang et al. (2022) indicate that rainfall and population size have a greater differential effect on rural tourism's spatial distribution than transport, tourism resources, and urban factors. Zhan et al. (2022) identified four key aspects: national development strategy, social environment, geographical environment and historical development. The COVID-19 pandemic also increased spatial restrictions on the mobility of tourists, which caused disparities in the recovery of different types of tourist destinations (Castanho et al., 2021; Li et al., 2022). Identifying factors influencing the formation of the spatial structure of tourism development is an important aspect in creating tourist areas in different countries (Skare et al. 2023a,b). At the same time, business entities are characterized by a different level of development, creating quantitative and qualitative disparities on the tourist market. As an example, results of the study (Walter et al., 2022) show that gourmet restaurants are more common in urban areas and on the way to tourist destinations.

Many scientists suggest determining the structure of a tourism market on the basis of spatial polarization by evaluating the ratio of key quantitative parameters that characterize growth rates in employment, wages, and establishments (Yang et al., 2023; Gavurova et al. 2023), accommodation base, tourism traffic, tourism-related expenditures and revenues (Roman et al., 2020). In (Zhu et al., 2022), characteristics of the spatial distribution of pro-poor tourism villages in China are described using disequilibrium index, kernel density analysis, and spatial autocorrelation. Selection of a method for studying the uneven development of regions should make it possible to distribute objects not by one parameter, but by a whole set of features (Reznakova et al., 2022). An incomplete, unreliable or low-quality data used for analysis does not allow for an objective assessment and thus reduces the effectiveness of the entire subsequent management process. Considering the existence of many economic connections between entities on the tourist market, it is necessary to take into account a set of indicators that would reflect all aspects of tourism development in the region and the influence of the most important factors. However, this principle is not always observed in scientific research. Based on a balanced system of indicators, scientists (Kozel et al., 2017; Zheng et al., 2022) propose financial indicators, social benefits, internal processes and training and growth for evaluating the level of tourism development.

The unevenness of the tourism market development in Ukraine by region is confirmed by the studies of Druzhynina (2017), Dutka et al. (2019), Horban et al. (2020), Vysochan et al. (2021b) etc.

Further analysis of spatial changes can contribute to the future coordinated development of different regions (Geng et al., 2022). This determines the need to study the clustering of the tourism market based on statistical methods.

Researchers (Ferreira et al., 2020; Horina, 2017; Korcsmáros et al. 2016; Lou, 2022) try to solve this problem by grouping individual territories, industries or other objects into homogeneous groups with similar parameters in order to further evaluate and improve their development within the selected groups. Creation of classification groups based on effective economic criteria is interesting both from the point of view of combining objects into homogeneous groups, and from the point of view of applying specific methods of analysis to identify special characteristics within these groups.

At the same time, assessing tourism development trends across the regions of Ukraine in order to identify attractive regions and differences in the territorial distribution of tourist flows, as well as to create strategies optimal for certain regions, taking into account their characteristics, remain less researched.

Cluster analysis in tourism

In recent years, cluster analysis methods in tourism have become widespread. Most of the works describe grouping of tourism companies. L. Zaburanna (2013), using the algorithm of fuzzy K-means, correlation-regression analysis and construction of fuzzy algorithms, grouped enterprises of rural agrarian tourism, and also investigated important factors of effectiveness of limited resources use for increasing business activity of rural agrarian tourism. A.V. Krushinska (2014) substantiated expediency of clustering tourism complexes and grouped them based on the Sturgess, Scott and Friedman/Diakonis' approaches to formation of the number of intervals in clustering. Another object of cluster grouping can be tourists. Thus, in (Vareiro et al., 2013) cluster analysis was used to separate Guimarães (Portugal) residents into clusters according to their perceptions of the impacts of tourism development, and in (Brida et al., 2010) – for segmentation of the mountain community in the north of Italy, in order to reveal heterogeneity of residents' perceptions of strategic tourism policy.

Cluster analysis is also popular to group administrative-territorial units (objects) according to indicators of tourism development. Ferreira, F., and Castro, C. (2020) grouped 46 European countries by factors determinig competitiveness in tourism, and Roman M. et al. (2022) grouped 31 European countries according to changes in the tourism sector in 2019-2020 in order to assess impact of the COVID-19 pandemic on European countries. However, the researchers used a hierarchical classification to group countries without further determining contribution of a certain classification feature to distribution of observations.

Results of clustering of administrative-territorial units of Ukraine are presented in studies of many scientists. H. Dutka, O. Savitska and N. Savitska (2019) grouped the regions of Ukraine according to indicators of activity of legal entities and individual entrepreneurs operating in tourism sector. Ya. Vasylevska (2013) grouped cities and districts of Kherson region according to tourism and recreational resources. In (Vlaschenko et al., 2020), using two methods of cluster analysis – hierarchical classification and K-means, – grouping of 20 districts of Lviv region was carried out and scientific and practical recommendations were developed for creation of clusters for boosting child and youth tourism. P. Karkalyova (2012) clustered districts of Kharkiv region into five groups according to the level of rural green tourism development potential using hierarchical agglomerative method of clustering according to the rule of hierarchical association – the Ward method and the Euclidean metric was chosen as a measure of similarity. Similar methods were used by V. Druzhinina (2017), H. Horyna (2017) for the distribution of regions of Ukraine according to indicators of the functioning of tourism companies. M. Syrotyuk and T. Snezhyk (2010) used cluster analysis to identify the main groups of villages in the mountainous regions of Lviv region and listed their characteristics for further analysis of recreational potential of the territory in accordance with needs of different types of vacationers.

Analysis of scientific research (Shiller et al., 1991; Yermak, 2017) enables singling out the following advantages of using cluster analysis: 1) it provides a more accurate and correct division of an input data set into homogeneous groups so that objects within the group are similar to each other, while objects of different groups differ from each other; 2) it makes it possible to distribute objects not by one parameter, but by a whole set of features; 3) it does not limit output data, and allows to freely consider a set of arbitrary objects. This is of great importance, in particular, for evaluating regions by the level of tourism development, if indicators have different sizes, scales and units of measurement, which complicates application of traditional econometric approaches. The identified advantages provide grounds for using cluster analysis in this study.

Thus, examonation of scientific works on cluster analysis showed that almost all studies are based on application of its traditional algorithms. However, it is known that cluster analysis algorithms are not universal, each has a specific field of use, advantages and disadvantages. The problem of quality and stability of division into groups remains relevant in cluster analysis (Khvalynska, 2018; Prokopenko et al., 2020). Another problem of the traditional algorithm of cluster analysis is strong dependence of the distance of objects from an initial center of a cluster (Lou, 2022). To eliminate this problem, scientists Ma, Z., & Liu, X. (2011) performed a principal component analysis, then used extracted principal components as a new integrated variable, the principal component score matrix as a new integrated variable data for cluster analysis through SPSS software.

Such problems in the application of traditional methods of cluster analysis necessitate their further modification to obtain more accurate results.

3. Methods

Cluster analysis is a multivariate statistical data processing method used to classify objects, that is, to divide them into groups or classes in such a way that the objects in each group were more similar to each other than to objects from other classes (Stabile, 1986).

Cluster analysis algorithms can be divided into hierarchical and non-hierarchical (Vysochan et al., 2021a). In our research, the algorithms of hierarchical agglomerative procedures using Euclidean metric are utilised as a basis. Its essence consists in the sequential merging of smaller clusters into large ones or the division of large clusters into smaller ones. This group of hierarchical agglomerative (Agglomerative Nesting, AGNES) methods is characterized by a consistent combination of initial elements and a corresponding reduction in a number of clusters. At the beginning of the algorithm, all objects are separate clusters. In the first step, similar objects are combined into a cluster. In subsequent steps, unification continues until all objects form one cluster (Shpak et al. 2021a).

Hierarchical methods of cluster analysis are used for small amounts of data. The advantage of hierarchical clustering methods is their visibility (Vertil, 2012; Chakraborty et al., 2021).

Let's now consider the task of researching heterogeneity of tourism development for the regions (oblasts) of Ukraine and the city of Kyiv (the number of research objects is $N = 25$), based on statistical data for 2020 on $K = 16$ indicators.

The need to modify the clustering method to solve this task is due to the following reasons:

1. Factors that characterize tourism development in the studied regions of Ukraine have different significance for clustering these regions.

2. In addition, due to the nature of their assessment, each of these factors has a correspondingly different measurement scale.

3. Results of a statistical study of the Ukrainian regions in the field of tourism are subject to probabilistic influences and cause deviations. Therefore, even identical objects can be evaluated differently.

Weighting factors are used to minimize impact of the first cause. Specifics of using this approach are actually in the application of weighting coefficients for each indicator (Onuferová et al., 2020; Podolchak et al., 2022).

Weighting coefficients of the importance of the indicators characterizing the tourism development of all regions are determined by the method of pairwise comparison of factors and are used in the following ratio:

$$\langle X_1 : X_2 : X_3 : \dots : X_K \rangle = \langle \lambda_1 : \lambda_2 : \lambda_3 \dots : \lambda_K \rangle. \quad (1)$$

Every value of λ_i was determined in percentages, which were converted into weighted coefficients according to the formula:

$$\eta_k = {\lambda_k}\Big/{\sum_{j=1}^{K} \lambda_j}, \quad k = 1, \dots, K \quad (2)$$

In order to level the influence of the second reason, we transform the primary statistical data for each indicator. $\{x_{k,1}; x_{k,2}; x_{k,3}; x_{k,4}; \dots; x_{k,N}\}$ into a set of dimensionless quantities $\{\vartheta_{k,1}; \vartheta_{k,2}; \vartheta_{k,3}; \vartheta_{k,4}; \dots; \vartheta_{k,N}\}$ according to the formula:

$$\vartheta_i^{(k)} = {x_{i,1}}\Big/{\sqrt{\frac{1}{N}\sum_{j=1}^{N}\left(x_{k,j}\right)^2}}, \quad k = 1, \dots, K, \ i = 1, \dots, N. \quad (3)$$

In order to minimize probabilistic effects, we use penalty functions when determining the distance between regions. The essence of the approach is to minimize impact of minor deviations (Kolková et al., 2022; Urbaniak, 2021). For this purpose, experts determine a size of the deviation range $\Delta x^{(k)}$ for each of the factors $X^{(k)}$, which are again transformed into dimensionless quantities according to the sample formula (3):

$$\Delta_k = {\Delta x_k}\Big/{\sqrt{\frac{1}{N}\sum_{j=1}^{N}\left(x_{k,j}\right)^2}}, \quad k = 1, \dots, K. \quad (4)$$

The penalty function is calculated according to the formula:

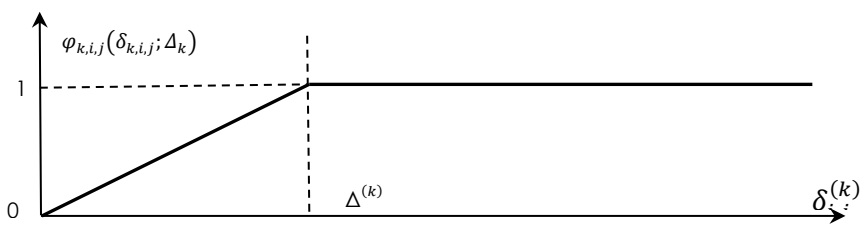
$$\varphi_{k,i,j}\left(\delta_{k,i,j}; \Delta_k\right) = \begin{cases} \frac{\delta_{k,i,j}}{\Delta_k}, \delta_{k,i,j} \le \Delta_k ; \\ 1, \quad \delta_{k,i,j} > \Delta_k , \end{cases} \quad (5)$$

where δ_k – deviation between the *i*-th and *j*-th regions according to the *k*-th indicator.

$$\delta_{k,i,j} = \left|\vartheta_{k,i} - \vartheta_{k,j}\right|, \quad k = 1, \dots, K, \ i = 1, \dots, N, \ j = 1, \dots, N. \quad (6)$$

General form of the penalty function is shown in Graph 1.

Graph 1. **Graphical interpretation of the penalty function**



The developed algorithm involves the application of a modified method of calculating distance measures with clarifying weight coefficients and corrective penalty functions for each indicator, which characterize the development of tourism in the regions of Ukraine.

The modified measure of the distance between two regions in the space of statistical indicators that describe the tourism potential of the Ukrainian regions is determined by the formula:

$$\mu_{i,j} = \sqrt{\sum_{k=1}^{K}\left(\eta_k \times \left(\vartheta_{k,i} - \vartheta_{k,j}\right)^2 \times \varphi_{k,i,j}\left(\delta_{k,i,j}; \Delta_k\right)\right)},\ i,j = 1,\dots,N, \quad (7)$$

where $\mu_{i,j}$ – measure of deviation between *i*-th and *j*-th regions; $\eta^{(k)}$ – weighting factor for a *k*-th indicator of the tourism development in Ukraine.

On the basis of the proposed method of calculating distance measures with clarifying weight coefficients and corrective penalty functions, an algorithm for cluster analysis of the regions of Ukraine based on indicators of tourism development was developed (Graph 2).

Graph 2. **Modified algorithm for cluster analysis of regions of Ukraine according to indicators of tourism development**

Stages	Description of the stages of cluster analysis
Stage 1. Selection of clustering objects	Objects of clustering are chosen: for our study, these are administrative and territorial units of Ukraine (25 regions: 24 oblasts and the city of Kyiv. In the system of administrative and territorial organization of Ukraine, Kyiv has a special status defined by the Constitution and it is not part of any oblast, although it is the administrative centre of Kyiv region)
⇩	
Stage 2. Formation of a database of indicators characterizing clustering objects	Indicators characterizing the development of tourism in the regions of Ukraine as of 2020 are chosen, in particular, indicators of the effectiveness of tourism companies and collective tourist accommodation, indicators of infrastructure and resource support for development of regional tourism (see table 1-2)
⇩	
Stage 3. Application of descriptive statistics	Main statistical indicators are calculated to describe the set of data characterizing development of tourism in the regions of Ukraine: average value, median, minimum and maximum value of the variable, standard deviation, coefficient of variation, range, kurtosis, coefficient of asymmetry, etc. (see Table 3)
⇩	
Stage 4. Standardization of indicators	Standardization of indicators is carried out in those cases when their units of measurement are different and need to be reduced to one dimensionless form, to ensure their comparability and relativity to eliminate the influence of different dimensions of values on a final result.
⇩	
Stage 5. Determining the importance of indicators and deviations for penalty	The importance of the indicators is determined by the method of the multicriteria approach by means of a pairwise comparison of the indicators (see Table 4). Deviations for calculation of penalty functions are also determined by the expert method (see Table 3)

functions	
Stage 6. Calculation of the Euclidean distance	Modified Euclidean metric with clarifying weight coefficients and corrective penalty functions for each indicator that characterizes the tourism development of the regions of Ukraine is used (see Table 5)
Stage 7. Determination of the optimal number of clusters and grouping of regions	The optimal number of clusters is determined for the iteration for which a value of the modified Euclidean distance does not exceed a threshold value of 0.66. Resulting groups of regions or individual regions are assigned to different clusters (see Graph 3)
Stage 8. Description of clusters and drawing conclusions	Characteristics of the clusters are calculated, similarity features of the formed clusters and problem points are determined, strategic directions of development of the clusters are established depending on their characteristic results

Source: developed by the authors

A list of the proposed indicators that characterize the level of tourism development in the regions of Ukraine is given in Table 1-2.

Table 1. **The proposed system of indicators characterizing tourism development of the regions of Ukraine**

Indicators	Legend	Units
Total cost of travel/tour packages (tickets) sold by tour operators and travel agents	X_1	Ukrainian hryvnia thousand
Number of tourists served by tour operators and travel agents	X_2	person
Number of tour packages sold by tour operators and travel agents	X_3	unit
Coefficient of capacity utilization of tourist collective accommodations	X_4	-
Export of travel-related services	X_5	US dollar thousand
Import of travel-related services	X_6	US dollar thousand
Number of foreigners who were in tourist collective accommodations	X_7	person
Number of overnight stays of foreigners in tourist collective accommodations	X_8	unit
Number of tourism companies in Ukraine	X_9	unit
Number of tourist collective accommodations	X_{10}	unit
Total number of bed-places in tourist collective accommodations	X_{11}	unit
Provision of restaurants for 10,000 people	X_{12}	units /10 thousand people
Provision of automobile roads per 1 thousand km of area	X_{13}	km / 1 thousand km^2
Number of monuments that are in the state register	X_{14}	unit
Specific weight of the area of the nature reserve fund (percentage of the area of an administrative-territorial unit)	X_{15}	%
Average registered number of full-time employees (of temporary accommodation and catering establishments)	X_{16}	person

Source: developed by the authors

For research, the indicators are proposed which values are objective and can be obtained from open sources. List of the indicators was formed taking into account principles of representativeness (the most significant indicators were selected that characterize the tourism sector), information availability (availability of statistical data for calculation of indicators) and reliability (indicators adequately reflect the level of development of the tourism sector). 16 indicators were selected that are officially collected, systematized and presented in open access by state bodies and structures, namely the State Statistics Service of Ukraine and the Ministry of Culture and Information Policy of Ukraine, were selected. The State Statistics Service of Ukraine publishes statistical information on tourism at its site www.ukrstat.gov.ua (section "Statistical information / Tourism"). The most important indicators from each group, which are presented by the State Statistics Service of Ukraine, were selected. In particular, from the section "Tourism activity in Ukraine" indicators X_1, X_2, X_3, X_9 were selected; from the section "Collective means of accommodation" – X_4, X_7, X_8, X_{10}, X_{11}, X_{16}; from the section "Regional statistics / Socio-economic situation of the region" – X_5, X_6, X_{15}; from the section "Activities of enterprises" – X_{12}, and from the section "Transport" – X_{13}. The Ministry of Culture and Information Policy of Ukraine maintains the State Register of Immovable Monuments, which became an information source for indicator X_{14}. Therefore, the indicators were selected to characterize the spheres related to tourism as fully as possible.

Table 2. **Value of the indicators characterizing the development of tourism in the regions of Ukraine in 2020**

Regions	Legend	Value of indicators															
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
Vinnytsia	C_1	325206.0	26470	12098	0.26	12702.5	818.6	264	483	79	10	1017	9.75	339.7	4329	2.27	677
Volyn	C_2	124924.7	10047	4401	0.24	176.1	7929.1	788	1546	70	36	1987	9.26	287.9	1529	10.93	570
Dnipropetrovsk	C_3	1128964.5	78100	36603	0.18	11700.6	10635.4	4447	12155	431	87	8047	11.16	288.2	11708	3.12	5056
Donetsk	C_4	218918.6	18672	9328	0.32	2236.7	1269.9	460	2227	82	65	7396	3.50	305.5	2192	3.78	2454
Zhytomyr	C_5	137234.6	11203	5031	0.26	129.6	192.8	591	4565	59	16	1193	10.41	281.6	6948	4.64	782
Zakarpattia	C_6	160271.0	14669	7188	0.18	6463.5	3050	782	1548	72	48	3905	19.49	266.6	1568	15.16	814
Zaporizhzhia	C_7	421983.9	33169	19019	0.24	10351.5	1261.5	1638	4786	147	119	16169	11.10	250.2	8906	5.08	1552
Ivano-Frankivsk	C_8	362021.9	62479	56767	0.21	7947.3	735.7	4842	14153	104	50	5002	13.56	294.4	3944	15.97	621
Kyiv	C_9	671051.1	47950	21307	0.21	1759.3	1918.9	7032	10672	220	80	9910	17.12	312.9	3606	10.4	3124
Kirovohrad	C_10	108227.7	7774	3918	0.20	189.9	1833.2	923	1228	57	20	1223	8.96	252.2	5021	4.08	156
Luhansk	C_11	47415.5	3411	1769	0.18	927.2	3657.6	480	6482	37	7	642	1.88	164.9	6152	3.49	200
Lviv	C_12	960213.0	100824	69155	0.14	12049.8	10704.9	20941	42243	265	111	12086	17.65	375.6	8479	8.15	9532
Mykolaiv	C_13	154469.1	11103	5741	0.28	1513.5	3775.3	1423	8292	89	83	11327	9.56	195.2	5877	3.14	941
Odesa	C_14	394952.4	28182	18405	0.17	26967.5	5380.6	8338	25264	194	147	21707	16.65	243.1	4449	4.63	4508
Poltava	C_15	253364.4	18993	8512	0.17	7806.6	3475.5	1554	5067	124	43	3393	11.34	309.6	4694	4.97	958
Rivne	C_16	228278.1	19269	8268	0.13	251.1	5744	564	1070	102	13	619	10.76	254.4	2365	9.95	527
Sumy	C_17	146452.2	12004	7334	0.14	6602.3	1039	924	1257	85	17	1300	8.53	281.1	2592	7.49	410
Ternopil	C_18	101270.3	8199	3168	0.10	10643.4	1943.8	863	1352	65	13	1269	8.83	361.7	4172	8.92	355
Kharkiv	C_19	654927.7	43989	24854	0.15	44099.7	2172.3	8322	20304	234	66	6698	14.32	299.2	9474	2.38	4685
Kherson	C_20	111325.9	13767	6928	0.25	617.8	376	896	2250	54	70	12582	13.01	175.7	5759	11.22	756
Khmelnytskyi	C_21	123373.1	11073	5893	0.18	92.5	3185.6	3743	4532	63	28	2078	12.24	349.0	2896	15.18	492
Cherkasy	C_22	187813.1	15761	8739	0.21	804.3	356.1	653	1351	99	43	3076	10.00	286.9	9103	3.1	470
Chernivtsi	C_23	82373.5	7825	4259	0.14	9164.1	9,8	350	4385	55	11	1135	12.94	358.2	2371	12.8	394
Chernihiv	C_24	194175.9	15849	6754	0.19	96.5	1347.8	1021	2025	57	22	1391	10.24	225.7	8897	7.86	1144
City of Kyiv	C_25	25457680.1	1739496	1062591	0.19	84501.2	579076.1	146489	251507	1023	132	19877	27.21	339.7	2584	25.3	23244

Source: www.ukrstat.gov.ua

4. Results

We applied descriptive statistics to determine the main statistical indicators for describing a set of variables characterizing tourism development in Ukraine's regions. In particular, a variable's mean, median, minimum and maximum value, standard deviation, coefficient of variation, skewness, kurtosis, and allowable deviations are calculated (Table 3).

Table 3. **Descriptive statistics of indicators characterizing the development of tourism in the regions of Ukraine in 2020**

Indicators	Mean	Median	Minimum value	Maximum value	Standard deviation	Coefficient of variation	Skewness	Kurtosis	Allowable deviations
X_1	1310275.5	194175.9	47415.5	25457680	5038273.8	384.52	4.98	24.83	25000
X_2	94411.12	15849	3411	1739496	343560.39	363.9	4.96	24.73	3000
X_3	56721.2	8268	1769	1062591	210217.43	370.62	4.95	24.65	5000
X_4	0.20	0.19	0.10	0.32	0.05	26.55	0.43	-0.04	0,02
X_5	10391.78	6463.5	92.5	84501.2	18351.36	176.59	3.22	11.52	500
X_6	26075.58	1943.8	9.8	579076.1	115247.12	441.97	4.99	24.96	500
X_7	8733.12	924	264	146489	29047.88	332.62	4.82	23.66	1000
X_8	17229.76	4532	483	251507	49740.19	288.69	4.72	22.94	5000
X_9	154.68	85	37	1023	201.75	130.43	3.68	15.18	5
X_{10}	53.48	43	7	147	41.32	77.26	0.82	-0.29	5
X_{11}	6201.16	3393	619	21707	6266.16	101.05	1.2	0.52	200
X_{12}	11.98	11.1	1.88	27.21	5.06	42.25	0.91	2.73	0.5
X_{13}	283.97	287.9	164.9	375.6	55.87	19.67	-0.44	-0.15	10
X_{14}	5184.6	4449	1529	11708	2859.42	55.15	0.66	-0.55	300
X_{15}	8.16	7.49	2.27	25.3	5.58	68.39	1.35	2.18	1
X_{16}	2576.88	782	156	23244	4824.16	187.21	3.65	14.88	200

Source: authors' calculations

From Table 3, it can be concluded that the values of the indicators in different regions vary greatly, which is confirmed by the minimum and maximum values, as well as the standard deviation and the coefficient of variation. Values of the coefficient of variation for indicators X_1–X_3, X_5–X_9, X_{11} and X_{16} exceed 100, which indicates a significant disproportion in the development of tourism in the regions of Ukraine according to these indicators. The import of travel-related services (X_6) is the variable with the greatest variability, indicating a significant impact of foreign economic relations with foreign countries on tourism development in the regions. Only for the indicator of provision of roads per 1,000 km of area (X_{13}) the asymmetry is negative, which shows a left-sided "skew" of the distribution series. That is, unfavorable deviations of a random variable from mathematical expectation will be the most likely. For sharper than normal distributions, kurtosis has positive values, and for flatter distributions – negative. The last column of Table 3 contains values of the deviation range $\Delta x^{(k)}$ for each of the factors $X^{(k)}$, determined by experts. This value will make it possible to minimize probabilistic influences when determining the measure of distance between regions.

The weights of the indicators are determined by the multicriteria approach by means of a pairwise comparison of the indicators (Table 4).

Table 4. **Matrix of pairwise comparisons of indicators**

Indicators	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	Cumulative frequency of preferences by a row (l_i)	Cumulative frequency of preferences by a column (m_i)	Cumulative frequency of preferences (l_i+m_i)	Weighting factor, w_j
X_1	–	X_1	X_1	X_1	X_5	X_1	X_1	X_1	X_1	X_1	X_1	X_1	X_1	X_1	X_1	X_1	14	0	14	0.118
X_2	–	–	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	X_2	14	0	14	0.118
X_3	–	–	–	X_3	X_3	X_6	X_3	X_3	X_3	X_3	X_3	X_3	X_3	X_3	X_3	X_3	12	0	12	0.101
X_4	–	–	–	–	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_4	X_4	X_{16}	2	0	2	0.017
X_5	–	–	–	–	–	X_6	X_5	X_5	X_5	X_5	X_5	X_5	X_5	X_5	X_{15}	X_{16}	8	2	10	0.084
X_6	–	–	–	–	–	–	X_6	X_6	X_6	X_6	X_6	X_6	X_6	X_6	X_6	X_{16}	9	3	12	0.101
X_7	–	–	–	–	–	–	–	X_8	X_7	X_7	X_7	X_7	X_7	X_7	X_7	X_7	8	1	9	0.076
X_8	–	–	–	–	–	–	–	–	X_8	X_8	X_8	X_8	X_8	X_{14}	X_{15}	X_{16}	5	2	7	0.059
X_9	–	–	–	–	–	–	–	–	–	X_9	X_9	X_9	X_9	X_9	X_9	X_{16}	6	1	7	0.059
X_{10}	–	–	–	–	–	–	–	–	–	–	X_{11}	X_{10}	X_{10}	X_{10}	X_{10}	X_{16}	4	1	5	0.042
X_{11}	–	–	–	–	–	–	–	–	–	–	–	X_{12}	X_{11}	X_{11}	X_{11}	X_{16}	3	2	5	0.042
X_{12}	–	–	–	–	–	–	–	–	–	–	–	–	X_{13}	X_{14}	X_{15}	X_{16}	0	2	2	0.017
X_{13}	–	–	–	–	–	–	–	–	–	–	–	–	–	X_{14}	X_{15}	X_{16}	0	2	2	0.017
X_{14}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X_{15}	X_{16}	0	3	3	0.025
X_{15}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X_{16}	0	4	4	0.034
X_{16}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	11	11	0.092
Total																	85	34	119	1

Source: authors' calculations

The calculated weighting coefficients (Table 4) demonstrate importance of indicators that characterize the development of tourism in the studied regions of Ukraine. The most significant are the cost of realized tourist packages (X_1) and the number of tourists served by tour operators and travel agents (X_2), and the least significant are the capacity utilization rate of collective means of accommodation (X_4), provision of restaurants (X_{12}) and provision of automobile roads (X_{13}).

Using modified Euclidean distance metric according to formula (7), it is possible to obtain a matrix of distances, which is a basis for cluster analysis of the regions of Ukraine (Table 5).

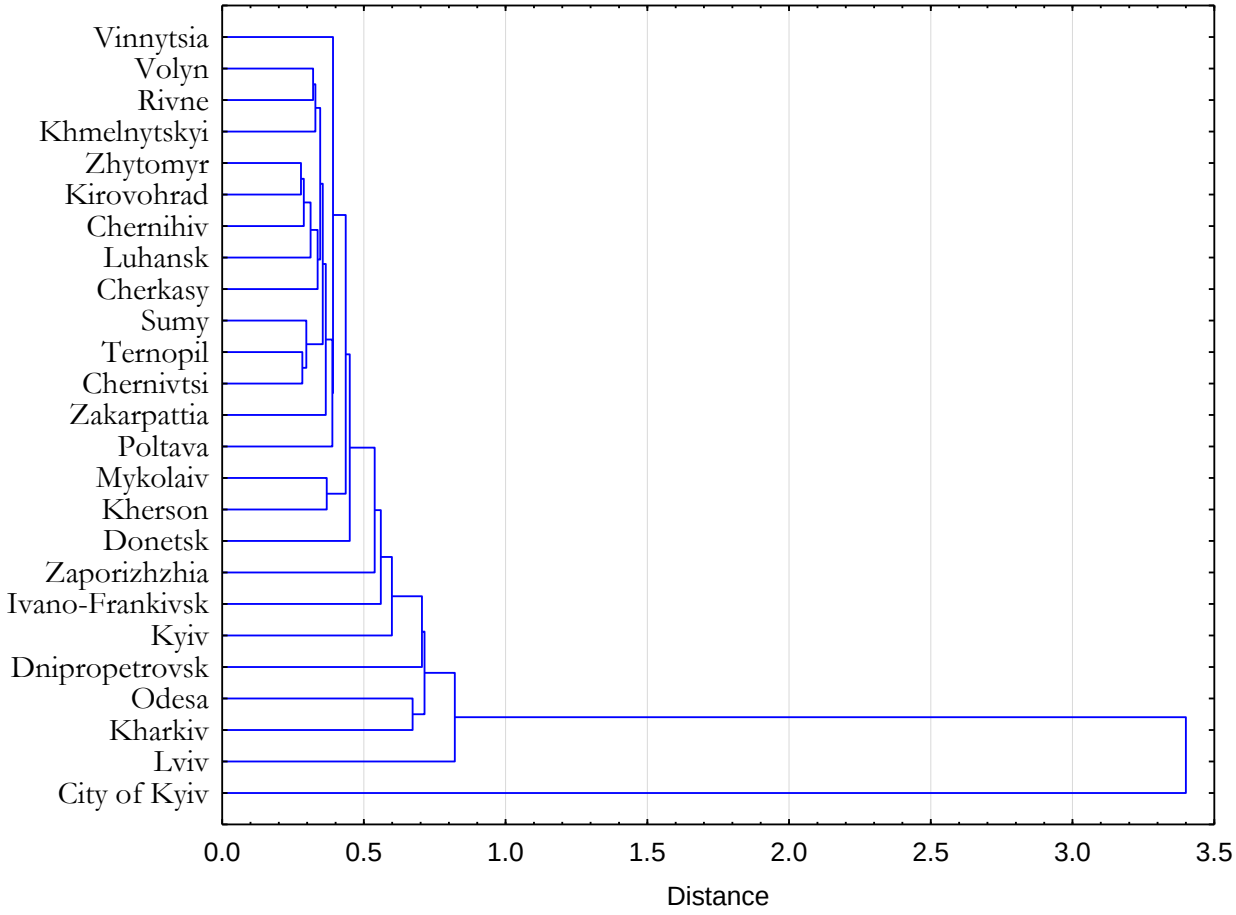
Table 5. **The distance matrix obtained using modified Euclidean metric**

Regions	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_10	C_11	C_12	C_13	C_14	C_15	C_16	C_17	C_18	C_19	C_20	C_21	C_22	C_23	C_24	C_25
C_1	0.000	0.527	0.867	0.550	0.462	0.504	0.604	0.627	0.755	0.479	0.530	1.108	0.589	0.877	0.439	0.476	0.407	0.391	0.894	0.593	0.555	0.475	0.441	0.496	3.567
C_2	0.527	0.000	0.934	0.506	0.367	0.392	0.706	0.660	0.715	0.346	0.442	1.148	0.495	0.956	0.477	0.321	0.388	0.432	0.994	0.438	0.329	0.396	0.437	0.382	3.576
C_3	0.867	0.934	0.000	0.840	0.925	0.904	0.768	0.796	0.705	0.945	0.952	0.821	0.850	0.828	0.827	0.930	0.915	0.914	0.773	0.915	0.933	0.886	0.935	0.909	3.474
C_4	0.550	0.506	0.840	0.000	0.497	0.496	0.597	0.681	0.599	0.514	0.561	1.088	0.450	0.857	0.483	0.511	0.506	0.580	0.886	0.475	0.552	0.455	0.585	0.489	3.560
C_5	0.462	0.367	0.925	0.497	0.000	0.473	0.659	0.676	0.727	0.278	0.354	1.153	0.454	0.949	0.449	0.384	0.382	0.433	0.963	0.436	0.382	0.342	0.425	0.288	3.587
C_6	0.504	0.392	0.904	0.496	0.473	0.000	0.643	0.566	0.695	0.475	0.540	1.115	0.515	0.906	0.389	0.438	0.366	0.436	0.941	0.457	0.403	0.447	0.411	0.452	3.560
C_7	0.604	0.706	0.768	0.597	0.659	0.643	0.000	0.669	0.635	0.694	0.727	0.986	0.554	0.714	0.538	0.692	0.649	0.656	0.844	0.588	0.712	0.619	0.678	0.637	3.529
C_8	0.627	0.660	0.796	0.681	0.676	0.566	0.669	0.000	0.645	0.691	0.724	0.989	0.673	0.881	0.560	0.651	0.617	0.648	0.874	0.662	0.604	0.639	0.622	0.673	3.524
C_9	0.755	0.715	0.705	0.599	0.727	0.695	0.635	0.645	0.000	0.744	0.774	0.923	0.625	0.749	0.667	0.704	0.733	0.770	0.752	0.649	0.688	0.701	0.765	0.704	3.512
C_10	0.479	0.346	0.945	0.514	0.278	0.475	0.694	0.691	0.744	0.000	0.312	1.171	0.485	0.959	0.473	0.371	0.355	0.379	0.981	0.461	0.381	0.354	0.426	0.325	3.590
C_11	0.530	0.442	0.952	0.561	0.354	0.540	0.727	0.724	0.774	0.312	0.000	1.178	0.498	0.973	0.513	0.434	0.446	0.452	0.994	0.523	0.451	0.434	0.458	0.423	3.594
C_12	1.108	1.148	0.821	1.088	1.153	1.115	0.986	0.989	0.923	1.171	1.178	0.000	1.079	0.942	1.073	1.141	1.132	1.125	0.974	1.105	1.143	1.130	1.140	1.130	3.400
C_13	0.589	0.495	0.850	0.450	0.454	0.515	0.554	0.673	0.625	0.485	0.498	1.079	0.000	0.848	0.468	0.531	0.527	0.578	0.922	0.369	0.517	0.446	0.595	0.486	3.562
C_14	0.877	0.956	0.828	0.857	0.949	0.906	0.714	0.881	0.749	0.959	0.973	0.942	0.848	0.000	0.840	0.939	0.925	0.925	0.672	0.894	0.943	0.929	0.943	0.941	3.467
C_15	0.439	0.477	0.827	0.483	0.449	0.389	0.538	0.560	0.667	0.473	0.513	1.073	0.468	0.840	0.000	0.448	0.395	0.444	0.873	0.522	0.476	0.406	0.461	0.448	3.559
C_16	0.476	0.321	0.930	0.511	0.384	0.438	0.692	0.651	0.704	0.371	0.434	1.141	0.531	0.939	0.448	0.000	0.356	0.431	0.978	0.492	0.385	0.387	0.438	0.367	3.576
C_17	0.407	0.388	0.915	0.506	0.382	0.366	0.649	0.617	0.733	0.355	0.446	1.132	0.527	0.925	0.395	0.356	0.000	0.297	0.950	0.506	0.416	0.401	0.329	0.389	3.575
C_18	0.391	0.432	0.914	0.580	0.433	0.436	0.656	0.648	0.770	0.379	0.452	1.125	0.578	0.925	0.444	0.431	0.297	0.000	0.949	0.540	0.451	0.481	0.283	0.447	3.574
C_19	0.894	0.994	0.773	0.886	0.963	0.941	0.844	0.874	0.752	0.981	0.994	0.974	0.922	0.672	0.873	0.978	0.950	0.949	0.000	0.963	0.972	0.925	0.966	0.947	3.462
C_20	0.593	0.438	0.915	0.475	0.436	0.457	0.588	0.662	0.649	0.461	0.523	1.105	0.369	0.894	0.522	0.492	0.506	0.540	0.963	0.000	0.467	0.443	0.527	0.436	3.565
C_21	0.555	0.329	0.933	0.552	0.382	0.403	0.712	0.604	0.688	0.381	0.451	1.143	0.517	0.943	0.476	0.385	0.416	0.451	0.972	0.467	0.000	0.440	0.412	0.398	3.570
C_22	0.475	0.396	0.886	0.455	0.342	0.447	0.619	0.639	0.701	0.354	0.434	1.130	0.446	0.929	0.406	0.387	0.401	0.481	0.925	0.443	0.440	0.000	0.504	0.337	3.581
C_23	0.441	0.437	0.935	0.585	0.425	0.411	0.678	0.622	0.765	0.426	0.458	1.140	0.595	0.943	0.461	0.438	0.329	0.283	0.966	0.527	0.412	0.504	0.000	0.472	3.573
C_24	0.496	0.382	0.909	0.489	0.288	0.452	0.637	0.673	0.704	0.325	0.423	1.130	0.486	0.941	0.448	0.367	0.389	0.447	0.947	0.436	0.398	0.337	0.472	0.000	3.581
C_25	3.567	3.576	3.474	3.560	3.587	3.560	3.529	3.524	3.512	3.590	3.594	3.400	3.562	3.467	3.559	3.576	3.575	3.574	3.462	3.565	3.570	3.581	3.573	3.581	0.000

Source: authors' calculations

Using the Statistica 10 program, the composition and number of clusters are presented using the construction of a dendrogram in the form of a graph of the clustering scheme (Graph 3). The presented diagram shows a stepwise graphical representation of the change in the distances of the Euclidean metric when clusters are merged. However, as one moves down the diagram, there is an increase in the distance between the clustering regions.

Graph 3. **Dendrogram of hierarchical clustering of regions of Ukraine according to indicators of tourism development, 2020**



Source: built on the basis of the authors' calculations

As a result of the cluster analysis based on indicators of the tourism sector development as of 2020, 6 clusters of regions of Ukraine were obtained:

1st cluster – city of Kyiv;
2nd cluster – Lviv region;
3rd cluster – Dnipropetrovsk region;
4th cluster – Odesa region;
5th cluster – Kharkiv region;
6th cluster – Kyiv, Zaporizhzhya, Ivano-Frankivsk, Vinnytsia, Mykolaiv, Poltava, Zakarpattia, Khmelnytsky, Cherkasy, Chernihiv, Volyn, Rivne, Donetsk, Chernivtsi, Luhansk, Kherson, Ternopil, Sumy, Zhytomyr, Kirovohrad.

In general, we can distinguish 3 groups of regions of Ukraine: 1) the city of Kyiv – a cluster with significantly higher values of indicators compared to other regions; 2) regions with an average level of tourism development (clusters 2-5) – regions characterized by well-known tourist destinations and

significant tourist potential; 3) regions of cluster 6 – regions with a low level of tourism development and which do not make a significant contribution to the development of tourism in Ukraine.

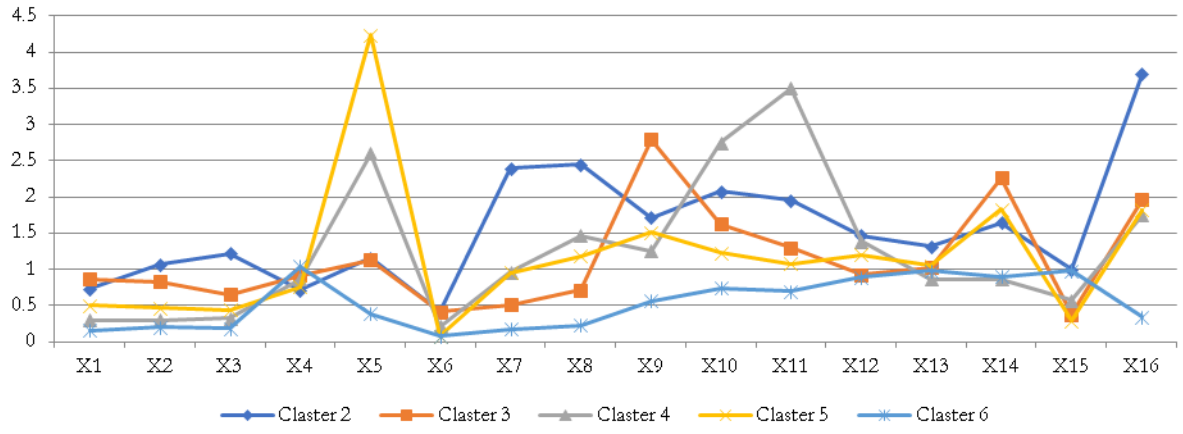
Table 6 shows the average values of standardized indicators within clusters of the regions of Ukraine, and Graph 4 – a graph of the average standardized values of indicators for each cluster. It was found that the values of indicators in the 1st cluster (Kyiv) are significantly (more than an interquartile range) higher than the values in all regions. Such a phenomenon is interpreted in data analysis as an "emission". In order to eliminate its influence, the data for cluster 1 in Graph 4 are excluded.

Table 6. **Average values of standardized indicators within clusters of regions of Ukraine in 2020**

Indicators / Clasters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
Claster 1 – Kyiv city	19.43	18.43	18.73	0.97	8.13	22.21	16.77	14.60	6.61	2.47	3.21	2.27	1.20	0.50	3.10	9.02
Claster 2 – Lviv region	0.73	1.07	1.22	0.71	1.16	0.41	2.40	2.45	1.71	2.08	1.95	1.47	1.32	1.64	1.00	3.70
Claster 3 – Dnipropetrovsk region	0.86	0.83	0.65	0.92	1.13	0.41	0.51	0.71	2.79	1.63	1.30	0.93	1.02	2.26	0.38	1.96
Claster 4 – Odesa region	0.30	0.30	0.32	0.86	2.60	0.21	0.96	1.47	1.25	2.75	3.50	1.39	0.86	0.86	0.57	1.75
Claster 5 – Kharkiv region	0.50	0.47	0.44	0.76	4.24	0.08	0.95	1.18	1.51	1.23	1.08	1.20	1.05	1.83	0.29	1.82
Claster 6 – other regions	0.16	0.20	0.18	1.04	0.39	0.08	0.17	0.23	0.56	0.74	0.70	0.89	0.98	0.90	0.98	0.34

Source: authors' calculations

Graph 4. **Average values of standardized indicators for each cluster in 2020**



Source: built on the basis of the authors' calculations

Graph 4 shows how the average values of the standardized indicators for each cluster are correlated. Cluster 6 is characterized by the lowest values of indicators among all clusters, except for indicators of the coefficient of capacity utilization of collective tourist accommodations (X_4), availability

of roads (X_{13}), number of monuments that are in the state register (X_{14}) and the specific weight of the area of the nature reserve fund (X_{15}). For cluster 2, the value of half of the indicators exceeds the value of the indicators of other clusters. The most variable within clusters are such indicators: export of travel-related services (X_5); number of foreigners who were in tourist collective accommodations (X_7); number of overnight stays of foreigners in tourist collective accommodations (X_8) – indicates disparities in the development of tourism clusters as a result of foreign economic factors influence; number of tourism companies in Ukraine (X_9); number of tourist collective accommodations (X_{10}); total number of bed-places in tourist collective accommodations (X_{11}) – indicates disparities in the development of tourism clusters as a result of infrastructure factors influence; average registered number of full-time employees (X_{16}) – indicates the uneven staffing of tourism development in the regions of Ukraine.

5. Discussion

On the basis of the obtained division of regions into groups according to indicators of tourism development, the following conclusions are drawn:

– 1st cluster (the city of Kyiv) has the highest values of most of the analyzed indicators, while it is inferior to other regions in terms of hotel business, availability of roads and number of monuments that are in the state register. It is worth noting significant differences in the development of tourism in Kyiv compared to other regions of Ukraine. Thus, the share of the number of tourists and tour packages sold by tour operators and travel agents in Kyiv exceeds 70% of the total volume in Ukraine. In addition, Kyiv is the leader in the import of travel-related services (88.8% as of 2020). Due to such a significant disproportionality in the development of tourism in Kyiv, scholars consider this city anomalous and often omit it when studying regions of Ukraine. The highest positions of the city in the rating are confirmed by other scientific studies (Horban et al., 2020; Shevchenko et al., 2020). However, during 2019-2020, there was a significant reduction in tourist collective accommodation utilization rate. From the leading position in 2019 (the indicator was 37% against the average value for Ukraine of 30%), the city dropped to 12th position in 2020 with an indicator value of 19%, which is lower than the average value for Ukraine (20%). The hotel industry of the cluster has significant potential for improvement and needs the introduction of modern approaches to stimulate tourism activity (Department, 2017);

– 2nd cluster – Lviv region. It is rich in unique objects of historical and cultural heritage, art, health and wellness, water and landscape resources, and unique traditions and customs, which, combined with a favorable geographical position, create significant potential for developing diverse types and forms of tourism and recreation. There are five UNESCO World Heritage sites in the Lviv region: the Ensemble of the Lviv historical center and four wooden churches. Lviv oblast belongs to the regions of Ukraine with the largest number of castles. Analyzing the current state of the region's tourism and recreation sphere, constant positive dynamics of its development in recent years should be emphasized first. This is reflected in the growth of tourism flows, gradual development of the region's tourism and recreational infrastructure, expansion of a range of tourism services, and growth of tourism services quality (Minregion, 2020a). Lviv region has the leading position after Kyiv in terms of the average number of full-time employees working in the field of temporary accommodation and catering organizations. In a previous study (Karyy et al., 2021), applying the mathematical apparatus of game theory and evaluating indicators of tourism companies in 2019, the authors obtained a similar result – Lviv region was singled out as the most attractive and the least risky for tourism activity in Ukraine. In many other studies (Borblik, 2019; Dutka et al., 2019; Vysochan et al., 2021b), scientists conducting a cluster analysis also single out Lviv region into a cluster characterized by the highest level of tourism development;

– 3rd cluster (Dnipropetrovsk region) has the leading position in terms of the number of monuments that are in the state register (11,708 units as of 2019). In terms of the number of tourists served by tour operators and travel agents and the number of travel companies, it is inferior to Kyiv and Lviv region. Priority tourism types in the region, as defined by the Ministry of Economic Development and Trade of Ukraine, are: rural, industrial, historical, cultural and educational. Along with this, before the military aggression, other types of tourism also were developing in the region: ecological (green); sports; event; religious (pilgrimage); health and wellness; educational; natural; ethnographic; urban; space; patriotic (DRC, 2020);

– 4th cluster is represented by Odesa region. Peculiarity of its economic and geographical location, favorable natural and climatic conditions, various natural healing resources, sandy beaches, developed network of waterways, railways and automobile highways cause rapid development of tourism and recreation. Specifics of tourist and excursion potential of the region is also determined by numerous monuments and museums, well-known historical and cultural reserves. Tourism industry is strategic for Odesa region, which has all prerequisites for intensive development of domestic and foreign tourism: geographical location, favorable climate, the largest seaport of Ukraine, a resort and recreation complex, transport, financial and socio-cultural infrastructure (Minregion, 2020b). Considering high values of indicators characterizing development of foreign tourism, the region needs to focus on creating and effectively promoting an attractive international image of the territory;

– 5th cluster is represented by Kharkiv region. Here, before the military invasion, there were strong prerequisites for developing tourism. Kharkiv region has a favorable geopolitical location, comfortable microclimatic conditions, diverse landscape, unique flora and fauna, historical, cultural and architectural heritage, developed network of transport connections, sufficient human and material resources, including natural health resources. Kharkiv region is a multi-disciplinary destination for summer and winter recreation, balneological treatment and mass educational tourism (KhRC, 2013). It has great potential for development of various types of tourism: cognitive (excursion), health, business, sports, amateur (hunting, fishing), green, ecological, religious, club, etc. (Erofeeva, 2008).

In scientific studies using cluster analysis, the regions of Ukraine, which we assigned to the first five clusters, are also objects of separate clusters. In (Horina, 2017), 5 clusters are distinguished based on indicators of tourism companies functioning: the first one includes the city of Kyiv, and the second – Lviv, Odesa, Kharkiv and Dnipropetrovsk regions. In (Pokataieva et al., 2017), according to the number of tourism companies and full-time employees, first two isolated clusters includes Dnipropetrovsk, Ivano-Frankivsk, Lviv, Odesa, and Kharkiv regions; according to income and expenses of tourism companies – Ivano-Frankivsk, Lviv, and Odesa regions; and according to number and value of tours sold – Ivano-Frankivsk, Lviv, Odesa and Kharkiv regions;

– 6th cluster includes all other regions of Ukraine characterized by average or low values of tourism development indicators. In these regions, tourism is supported mainly by small and medium-sized businesses (Danylkiv et al., 2021; Kulinich et al., 2022; Shpak et al., 2020). For balanced development of tourism in this cluster, it is expedient to evaluate existing tourism potential, determine priority tourism types by region and develop appropriate tourism products.

Unfortunately, the russian invasion of Ukraine led to a dramatic decrease in inbound tourist flow, negatively affected structure of tourism and realization of the country's tourism opportunities on the global tourism market. The regions that form clusters 3-5 (Dnipropetrovsk, Odesa, and Kharkiv regions) and some other regions from cluster 6 suffered significant losses from the military operations, which will most probably lead to loss of leadership positions in tourism in favor of other regions.

Ways to eliminate disproportions in functioning of the tourism industry identified within this study are to equalize social asymmetries at the level of the country, its regions, and their territorial units (Turskyi, 2017; Androniceanu et al., 2021; Androniceanu et al., 2022). Special attention should be focused on depressed and affected by the war territories, where processes of infrastructure destruction, outflow and degradation of human capital intensify against the background of excess supply of labor

and low standard of living of the population. Popularization, renovation, and preservation of objects of historical and cultural heritage; improvement of tourist infrastructure; diversification of tourism types; improving coordination in tourism; strengthening security and social responsibility will contribute to the formation/recovering of an attractive image of territories that due to certain circumstances, have got to the periphery of tourism development.

6. Conclusion

The proposed scientific and methodological approach to clustering regions of Ukraine makes it possible to identify groups of regions that are similar according to certain criteria characterizing the level of tourism development. As a result of the conducted research, certain conclusions were formed that made it possible to answer the research questions.

RQ1: Are there differences in the development of tourism in the regions of Ukraine?

The results of descriptive statistics confirm differences in tourism development in Ukraine's regions. Significant variations in the values of indicators in different regions of Ukraine were revealed. Furthermore, the average values of the standardized indicators for each cluster also show differences in tourism development in the regions of Ukraine. In particular, a statistical outlier was found for the first cluster (Kyiv), i.e., a deviation is greater than the interquartile range.

RQ2: What groups of regions (clusters) of Ukraine can be distinguished by the level of tourism development?

The optimal number of clusters was obtained to determine the modified Euclidean distance, which would not exceed the threshold value. Each cluster is formed from homogeneous regions of Ukraine in such a way that the regions within the cluster are similar, and the regions of different clusters differ. Thus, according to the tourism sector's development level, 6 clusters of regions of Ukraine were obtained. At the same time, the regions of some clusters have clearly expressed differences in tourism development compared to other clusters' regions. Therefore, characteristics and differences in tourism development for each region are described in the study.

Conditionally, according to cultural and historical principles, the territory of Ukraine is divided into 5 regions: west, north, east, center and south. Our research made it possible to single out regional clusters that clearly represent each of the geographical directions of Ukraine: Kyiv city and Dnipropetrovsk region – the center of Ukraine; Lviv region – the west; Odesa region – the south; Kharkiv region – the east of Ukraine. The last singled-out sixth cluster is headed by the Kyiv region, which represents the north of Ukraine. That is, there is a clearly expressed nature of dominance of the tourism development in one region representing a certain cultural and historical region of Ukraine. Historically, these regions are the most developed socio-economic and historical-cultural wise, which gave them privileges and additional opportunities in tourism development. Therefore, lower tourism development indicators characterize all other regions of Ukraine and can be conditionally characterized as "complementary" to "leader regions". The authors of (Vysochan et al., 2021b), using attribute-cluster analysis, also concluded that there are clear priorities for the development of certain types of tourism in the geospatial context of Ukraine: the north-eastern direction – priority development of business tourism; the southern direction – recreational tourism; the western direction – health tourism; the center – cultural and historical tourism.

There are several policy implications in our study. The results may allow the Ministry of Economy of Ukraine, the Ministry of Development of Communities and Territories of Ukraine, the Ministry of Culture and Information Policy of Ukraine, the State Agency for Tourism Development, and other relevant state authorities to:

– ensure comprehensive development of territories, in particular, create favorable conditions for attracting investments in tourism infrastructure development (ODA, 2020);

– form and implement competitive regional tourism products, which can contribute to the growth of demand for tourism services (Grobelna, 2019), and increase revenues from tourism to state and local budgets (ODA, 2020);

– make decisions regarding state stimulation of certain regions in order to activate the development of entrepreneurship according to specific criteria (Turskyi, 2017);

– increase the level of international competitiveness of all participants of the tourism market (Grančay, 2020) and create differentiated strategies for the development of groups of regions;

– optimize state funding and promote the development of the most promising tourism destinations;

– ensure more effective use of material and non-material resources at regional and state levels;

– increase the efficiency of tourism companies and enterprises working in related industries (Zielinska et al., 2016).

This study's scientific novelty consists of the author's algorithm for conducting a cluster analysis of the regions of Ukraine according to indicators of tourism development. This algorithm, unlike the existing ones, made it possible to consider clarifying weight coefficients and corrective penalty functions for each indicator to minimize probabilistic influences when determining distance between objects. As a result, the authors singled out six clusters and found peculiarities of tourism development within each.

However, the study has some limitations. Cluster analysis was performed only on selected indicators based on available data. The methodology can be reconstructed using other indicators. Other multicriteria analysis methods can be used to assess the obtained results.

Considering the war taking place on the Ukrainian territory and dynamic global changes in tourism, it is worth continuing the research, for example, by choosing other diagnostic variables. It is also expedient to include in the research qualitative indicators (e.g., quality of tourism services, level of satisfaction with hotel services, etc.), the assessment of which requires additional resources and time.

The practical value of the research is that, although it is based on statistical data of Ukraine only, the cluster analysis technique modified by the authors can be used in other countries to identify disparities and group territorial units according to indicators characterizing the level of development of the tourism sector. Even though this topic is widely analyzed in foreign scientific research (Chang et al., 2022; Li et al., 2022; Lou, 2022; Ma et al., 2011; Prokopenko et al., 2020; Roman et al., 2020; Vareiro et al., 2013; Zhu et al., 2022), the author's algorithm will allow to more accurately divide the set of input data into homogeneous groups so that the objects within the group are similar to each other, and the objects of different groups differ from each other. The author's improved method of cluster analysis will make it possible to get rid of other shortcomings, which are described in the previous section.

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