

# The Impact of the Russian-Ukrainian War on the Development of the Primary Residential Real Estate Market in Ukraine: Results of a Cluster Analysis

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## ABSTRACT

The war started by the Russian Federation has caused significant damage to all areas of the life of Ukrainians. The realities of the Russian-Ukrainian war have led to an increase in prices in the primary market of residential real estate, a decrease in the number of new buildings for sale, and a decrease in the percentage of the area of residential buildings put into operation compared to the period of the previous year, and a decrease in the number of apartments sold. Like other areas of the economy, the real estate market has experienced significant upheavals. The research showed that each region was affected differently by the consequences of the Russian-Ukrainian war. The article groups the areas of Ukraine according to the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market. To achieve this goal, an agglomerative hierarchical type of clustering was used. To measure the distance between objects, the Euclidean distance is calculated. The complete linkage method was used to determine the distances between clusters. For the study, those indicators that best characterize the changes in the functioning of the market and are publicly available were chosen, in particular: average price per month, number of new buildings for sale, the total area of the residential buildings put into operation, number of registered internally displaced persons. Clustering made it possible to identify disparities in the development of Ukraine's regions. According to the cluster analysis results, 5 clusters of areas of Ukraine were distinguished according to the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market. The heterogeneity in the adaptation of the real estate market to the conditions of military operations and its evolution during the war should be taken into account by state authorities when developing strategies for the restoration of territories and forming optimal measures for the growth of the real estate market for a particular region, taking into account its characteristics.

## HIGHLIGHTS

- ① The article groups the areas of Ukraine according to the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market. To achieve this goal, an agglomerative hierarchical type of clustering was used.
- ② The heterogeneity in the adaptation of the real estate market to the conditions of military operations and its evolution during the war should be taken into account by state authorities when developing strategies for the restoration of territories and forming optimal measures for the growth of the real estate market for a particular region, taking into account its characteristics.

**Keywords:** Russian-Ukrainian war, real estate market, residential real estate, regions of Ukraine, cluster analysis.

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The war started by the Russian Federation has caused significant damage to all the areas of the life of Ukrainians – material (in the form of destruction of buildings, enterprises, and infrastructure), financial (the loss of tax and customs revenues to the state budget), human (deaths of military and civilians, injuries, the deterioration of mental health of the population, population migration to other countries), cultural (the destruction of cultural institutions and monuments, the deterioration of relations between Ukrainians and the residents of the country-aggressor), etc. According to the preliminary assessment by the IMF, the economy of Ukraine will shrink by approximately 45 % due to the war. The Russian-Ukrainian war, as well as subsequent trade restrictions, became a powerful trigger that significantly increased the level of inflation and exacerbated existing economic problems. The confrontation between the West and Russia will have a long-term, large-scale negative impact on the economy of most European countries.

The economic consequences of the war in Ukraine are felt all over the world. The Russian aggression has put pressure on global commodity prices, exacerbated disruptions in supply chains, and contributed to inflation in most countries around the world. According to the forecast of the Economist Intelligence Unit (EIU), global growth will deteriorate by 1.4 percentage points to 2.8 % on an annual basis, which will lead to the loss of a trillion dollars in global GDP. According to the forecast of the International Monetary Fund, the growth of the world economy will slow down to 3.2 % in 2022 compared to the April forecast of 3.6 %.

One of the items of losses of the Ukrainian economy in the war with the Russian occupiers is the amount of destroyed housing stock. During the period of the full-scale war and the arbitrariness of Russian barbarians on Ukrainian lands, according to the Center for Strategic Communications and Information Security of Ukraine, about 800,000 Ukrainians lost their homes as a result of the Russian invasion. In search of shelter, Ukrainians are forced to flee to safer regions of our country or abroad. According to the Deputy Head of the parliamentary committee on the organization of state power Olena Shuliak, “since the beginning of the war and as of the beginning of July, the

occupiers have destroyed about 15 million square meters of housing”. As of August 8, according to the calculations of the Kyiv School of Economics, at least 15,300 high-rise buildings and 115,900 private houses have been damaged or destroyed since the beginning of Russia’s war against Ukraine. The direct losses from the destruction of high-rise buildings amount to \$42.3 billion, private houses – \$5.4 billion.

Given the significant amount of losses in the residential real estate market, the state is faced with the challenges of the urgent restoration of residential facilities. The solutions in this direction are the reconstruction of housing for Ukrainians or the payment of compensations. The government has allocated UAH 1.5 billion from the reserve fund for the prompt restoration of housing and more than UAH 2.7 million from the reserve fund of the state budget to regional military administrations to support homeowners who provided shelter to forced migrants free of charge. It is about partial compensation for communal utility services for March. Such compensation is provided by the social program “Prykhystok (Shelter)”. However, these funds are not enough for the complete restoration of the destroyed housing stock of Ukrainians. Also, as a result of the military operations, the construction market has suffered significant losses, in particular, due to the increase in the price of construction materials, the increase in the dollar exchange rate, and the decrease in the purchasing power of the population. Since April, housing construction and sales have partially resumed, however, due to the high risks of the unstable situation, many investors refrain from buying. The fall in sales is characteristic of all the regions of Ukraine, including the western regions, which are relatively safe. The heterogeneity of the restoration and functioning of the real estate construction and sale market is necessary for the authorities to further form a financing strategy for the restoration and construction of new housing, optimal redistribution of funds, and directing larger amounts to those regions that need it most. The war is still going on, and Ukraine is constantly suffering new losses, and this requires new research taking into account current realities and making timely management decisions to support the development of the state’s economy. Grouping the regions of Ukraine according to the level of influence of the

Russian-Ukrainian war on the development of the primary market of residential real estate will allow identifying the regions that need help in the first place, regions with greater development potential and greater readiness for post-war reconstruction.

Taking into account the above considerations, the purpose of the research is to group the regions of Ukraine according to the level of influence of the Russian-Ukrainian war on the development of the primary market of residential real estate by using cluster analysis, which will make it possible to identify disparities in the development of regions and allow developing optimal measures for the development of the real estate market for a certain region, taking into account its features.

The structure of the article is as follows. The section "Review of literature" presents the theoretical foundations of the review of scientific sources on the issues of research. In the "Materials and methods" section, the information base is presented and the methodology of cluster analysis is described. The next section presents the results of cluster analysis and grouping of the regions of Ukraine according to the indicators of the development of the primary residential real estate market. Finally, the discussion and conclusions of the conducted research are presented.

## Literature Review

Given that the war has been going on for half a year at the time of writing, this period is quite short for conducting and publishing thorough research on this issue. First of all, research by scientists is aimed at a general assessment and analysis of the impact of the Russian-Ukrainian war on the economy of Ukraine and other countries. Possible changes in international currency payment systems, international trade, global supply chains caused by war, and imposed sanctions are being studied. Scientists and society are concerned about the possible negative consequences of the impact of the war on the environment and ecosystem. Much research is aimed at studying the impact of the war on the functioning of the stock market, the medical field, the market of tourist services, etc.

The full-scale war has hit the real estate market of Ukraine painfully. For a few months after the Russian invasion, the market froze – the registers did

not work, no houses were built, and no transactions took place. The process of returning to normal work was slow. From April to May, offers for the sale of housing began to appear again on classified sites. The analysis of the dynamics and statistics of the development of the real estate market in Ukraine, in particular the market of new buildings, is regularly published by the news agency "LUN" LLC. In general, builders in Ukraine have returned to work with more than 80 % of new buildings. In Kyiv, this indicator is 60 %, in the western regions – up to 90 %, in the south, in particular in the Odesa region – 66 % of new buildings continue sales and construction. In March 2022, the "Useful Map LUN City" was launched to help Ukrainians find pharmacies, gas stations, and supermarkets operating during the war. At the end of April, the project team added the "Derussification" layer to the map, which marks the renamed streets of Ukraine. Now, you can monitor how life is returning to the country's construction sites on the map.

The economic and mathematical apparatus found its practical application in the works of scientists for grouping the regions of Ukraine according to certain parameters. For example, in source, the scientists applied the mathematical apparatus of a game theory to evaluate the tourist attractiveness of the regions of Ukraine under conditions of uncertainty. The scientists grouped the regions of Ukraine according to the level of riskiness of the subjects of tourist activity. Another group of scientists proposed an approach based on the representation of regions in the space of partial consensus ratings of the economic and social development separately, followed by the identification of the stratification of objects in this space for grouping the regions of Ukraine by the level of socio-economic development. At the same time, the cluster analysis method has gained the greatest practical application for grouping research objects, in particular in such areas as archeology, medicine, psychology, biology, chemistry, public administration, philology, sociology, and other disciplines. In economic research, cluster analysis is often used to group such objects as enterprises, consumers, as well as administrative and territorial units. Taking into account the dynamics of the development of events, the relevance of the research, and the lack of thorough research on this

issue, the authors consider it expedient to apply cluster analysis to identify the regions of Ukraine that have suffered similar losses in the functioning of the primary residential real estate market as a result of the Russian-Ukrainian war. Cluster analysis will be used to single out homogeneous sub-clusters of objects in the studied totality; in this case, these are the regions of Ukraine.

## MATERIALS AND METHODS

To identify the impact of the Russian-Ukrainian war on the changes in the development of the regional market of the primary real estate in Ukraine, the authors suggest using a system of indicators (Table 1). Those indicators that best characterize changes in market functioning and are publicly available were chosen for the research.

**Table 1:** Indicators for assessing the impact of the Russian-Ukrainian war on the development of the primary residential real estate market

No.	Indicator	Data source
1	Average price per month, hryvnias/m <sup>2</sup>	Real estate market statistics/ / <a href="https://misto.lun.ua/price">https://misto.lun.ua/price</a>
2	Number of new buildings for sale, units.	Real estate market statistics/ / <a href="https://misto.lun.ua/price">https://misto.lun.ua/price</a>
3	Total area of the residential buildings put into operation, in % compared to the corresponding period of the previous year	State Statistics Service of Ukraine / <a href="https://www.ukrstat.gov.ua/operativ/operativ2014/bud/budo20_u.html">https://www.ukrstat.gov.ua/operativ/operativ2014/bud/budo20_u.html</a>
4	Number of registered internally displaced persons, persons	Report on the internal displacement in Ukraine for the 9 <sup>th</sup> round / <a href="https://dtm.iom.int/reports/україна-—звіт-про-переміщення-—звіт-по-базовій-оцінці-території-районний-рівень-—9-тур">https://dtm.iom.int/reports/україна-—звіт-про-переміщення-—звіт-по-базовій-оцінці-території-районний-рівень-—9-тур</a>

*Source:* Suggested by the authors.

A significant factor influencing the change in the values of each of the proposed indicators is the Russian-Ukrainian war, which causes an increase in prices and a decrease in the business activity of construction companies. This leads to a decrease in the number of new buildings for sale, a decrease in the area, and the number of residential buildings put into operation. IDPs can influence supply growth. As is known from the classical economic

theory, demand creates supply. The demand for new buildings is formed by those who are interested in buying an apartment – these can be newly formed families; investors who invest in the purchase of real estate to save funds or put them into circulation (renting out an apartment); parents who buy for their children; as well as in wartime, one of the important target categories of buyers is internally displaced persons (IDPs), whose desire is to buy a new home in regions that are safe and where hostilities are not taking place. Here it is worth pointing out that the decision of an IDP to buy an apartment is influenced by a wide range of factors: the buyer's financial paying capacity to pay, proximity to work, relatives, acquaintances, family composition, plans for the future, etc. In addition to price decisions, such factors as the type of region (city, village, mountainous area, proximity to the sea), the type of housing (own house, cottage, apartment building), available infrastructure (availability of public transport, business environment), etc. have an impact too. According to the results of the survey conducted by the sociological group "Rating" in May 2022 in large cities of the Lviv region, 26 % of migrants would like to stay or find work in the Lviv region, another 30% are ready to consider such a prospect. And this fact additionally creates a demand for the construction of new housing. It is also worth adding state or local funding programs for the construction of housing for IDPs, in particular modular houses, which is also a significant factor in the change of the place of residence for IDPs. One of these steps is the approval by the Government of the procedure for the formation of housing funds for temporary residence on April 20. This decision expands the mechanisms for providing housing for forced migrants and is part of the authorities' comprehensive work on solving the problems of IDPs. Housing will be built in the regions where hostilities are not ongoing and according to typical projects, using modern technologies of rapid construction. The works will be financed at the expense of the state, the funds of the authorized capital of the State Youth Housing, local budgets, international donors, and voluntary contributions of individuals and legal entities.

To assess the impact of the Russian-Ukrainian war on the development of the primary residential

**Table 2:** Input values of the indicators for analysis

Regions of Ukraine	Average price per month, UAH.		Number of new buildings (units) for sale as of:		Total area of the residential buildings put into operation in January-March 2022 (in % compared to the corresponding period of the previous year)	Number of the registered internally displaced persons, persons
	February	July	February	July		
Vinnitsya	22 200	29 000	42	41	63.5	193 864
Volyn	19 400	23 000	42	33	51.1	60 136
Dnipropetrovsk	27 900	34 500	72	46	26.8	281 693
Zhytomyr	17 900	21 900	28	20	64.9	75 301
Zakarpattia	23 900	36 800	47	40	58	175 429
Zaporizhzhya	19 500	21 800	25	6	103.3	168 102
Ivano-Frankivsk	15 600	19 500	95	90	46.4	99 983
Kirovohrad	15 000	18 400	3	2	34.6	81 202
Lviv	22 900	28 900	216	202	56.7	94 502
Odesa	24 200	31 500	172	112	41.2	92 700
Poltava	20 700	24 900	55	38	105.6	193 957
Rivne	18 300	25 500	47	43	46	75 047
Sumy	17 900	20 000	23	10	26.1	51 172
Ternopol	17 000	21 000	67	72	26	81 919
Khmelnyskiy	15 100	19 000	97	91	47	106 262
Cherkasy	18 300	20 000	25	27	33.8	144 447
Chernivtsi	21 100	29 800	51	44	45	73 626
Chernihiv	15 400	20 100	27	9	39.1	77 038
City of Kyiv	35 700	44 500	221	148	185.7	121 126

Source: Compiled by the authors.

**Table 3:** Increases in the indicators during the period of the Russian-Ukrainian war

Regions of Ukraine	Conditional designation of the region	Average price increase per month (July / February), %	Increase in the number of new buildings for sale (July / February), %	Increase in the area of residential buildings put into operation (January–March 2022 / January–March 2021), %	Number of the registered internally displaced persons (February 24 – August 5), persons
Conditional designation of the indicator		$X_1$	$X_2$	$X_3$	$X_5$
Direction of the change		disincentive	stimulator	stimulator	stimulator
Vinnitsya	C_1	30.6	-2.4	-36.5	193864
Volyn	C_2	18.6	-21.4	-48.9	60136
Dnipropetrovsk	C_3	23.7	-36.1	-73.2	281693
Zhytomyr	C_4	22.3	-28.6	-35.1	75301
Zakarpattia	C_5	54.0	-14.9	-42	175429
Zaporizhzhya	C_6	11.8	-76.0	3.3	168102
Ivano-Frankivsk	C_7	25.0	-5.3	-53.6	99983
Kirovohrad	C_8	22.7	-33.3	-65.4	81202
Lviv	C_9	26.2	-6.5	-43.3	94502
Odesa	C_10	30.2	-34.9	-58.8	92700
Poltava	C_11	20.3	-30.9	5.6	193957
Rivne	C_12	39.3	-8.5	-54	75047
Sumy	C_13	11.7	-56.5	-73.9	51172
Ternopol	C_14	23.5	7.5	-74	81919
Khmelnyskiy	C_15	25.8	-6.2	-53	106262
Cherkasy	C_16	9.3	8.0	-66.2	144447
Chernivtsi	C_17	41.2	-13.7	-55	73626
Chernihiv	C_18	30.5	-66.7	-60.9	77038
City of Kyiv	C_19	24.6	-33.0	85.7	121126

Source: Calculated by the authors.

**Table 4:** Descriptive statistics of the indicators

Indicators	Mean	Median	Minimum	Maximum	Standard deviation	Coefficient of variation
X <sub>1</sub>	25.9	24.6	9.3	54	10.7	41.39
X <sub>2</sub>	-24.2	-21.4	-76	8	23.54	-97.37
X <sub>3</sub>	-42.1	-53.6	-74	85.7	38.09	-90.54
X <sub>4</sub>	118289.8	94502	51172	281693	59756.93	50.52

*Source:* Calculated by the authors.

real estate market, it is necessary to analyze the change in the values of the indicators before the start of the war and after its end. At the time of writing, the war in Ukraine has been going on for 6 months. The article uses the indicators published in public sources at the time of writing the article. Table 2 shows the values of the analyzed indicators. However, due to the lack of data on some regions, as well as the impossibility of collecting data in the regions that were temporarily occupied, Kyiv, Mykolaiv, Kharkiv, Kherson, Luhansk, and Donetsk regions were excluded from the analysis.

The authors will apply descriptive statistics to determine the main statistical indicators for describing a set of indicators that characterize the development of the primary residential real estate market in the regions of Ukraine. Table 4 shows the values of the following parameters: average value, median, minimum and maximum value, standard deviation, and the coefficient of variation. The large value of the coefficients of variation indicates significant heterogeneity in the development of the real estate market in the regions of Ukraine.

Table 5 shows the matrix of Pearson correlation coefficients. It should be noted that the indicators selected for analysis are characterized by a fairly weak correlation (which does not exceed 0.6). The indicated correlations are significant only at  $p < 0.5000$  level.

**Table 5:** Matrix of Pearson correlation coefficients

Indicators	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>
X <sub>1</sub>	1.00			
X <sub>2</sub>	0.26	1.00		
X <sub>3</sub>	-0.06	-0.23	1.00	
X <sub>4</sub>	0.02	-0.03	0.19	1.00

*Source:* Calculated by the authors.

The assessment of a complex phenomenon, such as determining the impact of the Russian-Ukrainian

war on the development of the primary market of residential real estate in the regions of Ukraine, is possible using various methods, including cluster analysis.

Cluster analysis groups data objects based on the information contained only in the data that describe the objects and their relationships. The purpose is for objects in a group to be similar (or related) to each other and different from the objects in other groups. The greater the similarity (or homogeneity) within a group is, the greater the difference between the groups is, and the better or clearer clustering is carried out.

The research uses an agglomerative hierarchical type of clustering, which consists in a successive combination of smaller clusters into larger ones or a division of larger clusters into smaller ones. This group of methods is characterized by a successive combination of initial elements and a corresponding reduction in the number of clusters. At the beginning of the algorithm, all objects are separate clusters. In the first step, the most similar objects are combined into a cluster. In the following steps, the merging continues until all objects form a single cluster.

The advantage of hierarchical clustering methods is their visibility. The graphic result of clustering is a dendrogram – a tree-shaped diagram containing  $n$  levels, each of which corresponds to one of the steps of the process of the successive consolidation of clusters. A dendrogram is also called a tree diagram, a tree of cluster merging, and a tree of a hierarchical structure.

To measure the distance between the objects, the authors will use the most popular measure of similarity – the Euclidean distance. The Euclidean distance is the straight-line distance between two points in a multidimensional space. It is calculated using the following formula:

$$d_E(p, q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \dots + (p_n - q_n)^2} \quad \dots(1)$$

where  $n$  represents a number of dimensions or variables under consideration, and  $p$  and  $q$  represent the corresponding measures of two points on each of the dimensions. A variation of this distance is the squared Euclidean distance, which eliminates the square root operation in the formula to give more weight to outliers. The result of the Euclidean distance is that features with a higher variance will tend to dominate other variables.

In the research, a full linkage method was used to determine the distances between clusters, which lies in determining the largest distance between any two objects in different clusters (i.e., the “farthest neighbors”).

The standardization of indicators is carried out in those cases when their measurement units are different and they need to be brought to a single dimensionless form, to ensure their comparability and proportionality to eliminate the influence of different dimensions of the values on the resulting integral index. The different direction of changes for stimulating indicators and disincentive indicators also requires different formulas for their standardization.

In this case, stimulating indicators are those indicators whose growth demonstrates the

deterioration of the situation in the region in the real estate market and indicates the negative direction of the influence of the Russian-Ukrainian war, and disincentive indicators are those indicators whose growth, on the contrary, demonstrates the improvement of the situation in the real estate market.

The standardization of indicators is carried out according to the following formulas:

– for stimulating indicators:

$$z_i^j = \frac{x_i^j - \bar{x}_i}{\sigma_i} \quad \dots(1)$$

where  $\bar{x}_i$  is the average value of the indicator;  $\sigma_i$  is a standard deviation of the indicator.

– for disincentive indicators:

$$z_i^j = \frac{\bar{x}_i - x_i^j}{\sigma_i} \quad \dots(2)$$

The Statistica 10 statistical analysis software package was used for parameter calculations and cluster analysis.

## RESULTS

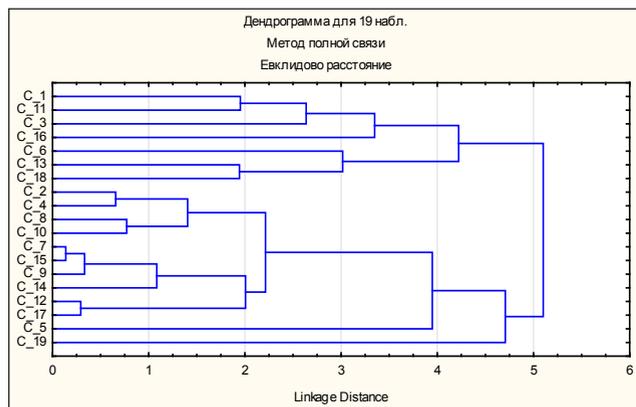
The results of the standardization of the indicators are shown in Table. 6.

**Table 6:** Results of the standardization of the indicators

Regions of Ukraine	Conditional designation of the region	Standardized values of the indicators			
		$X_1$	$X_2$	$X_3$	$X_4$
Vinnitsya	C_1	-0.455	0.950	0.150	1.299
Volyn	C_2	0.697	0.121	-0.184	-1.000
Dnipropetrovsk	C_3	0.207	-0.520	-0.840	2.809
Zhytomyr	C_4	0.342	-0.193	0.188	-0.739
Zakarpattya	C_5	-2.701	0.405	0.002	0.982
Zaporizhzhya	C_6	1.349	-2.262	1.224	0.856
Ivano-Frankivsk	C_7	0.082	0.824	-0.311	-0.315
Kirovohrad	C_8	0.303	-0.398	-0.630	-0.638
Lviv	C_9	-0.033	0.772	-0.033	-0.409
Odesa	C_10	-0.417	-0.468	-0.452	-0.440
Poltava	C_11	0.534	-0.293	1.286	1.301
Rivne	C_12	-1.290	0.684	-0.322	-0.743
Sumy	C_13	1.359	-1.411	-0.859	-1.154
Ternopyl	C_14	0.226	1.383	-0.862	-0.625
Khmelnyskiy	C_15	0.006	0.785	-0.295	-0.207
Cherkasy	C_16	1.589	1.404	-0.651	0.450
Chernivtsi	C_17	-1.473	0.457	-0.349	-0.768
Chernihiv	C_18	-0.446	-1.856	-0.508	-0.709
City of Kyiv	C_19	0.121	-0.385	3.447	0.049

Source: Calculated by the authors.

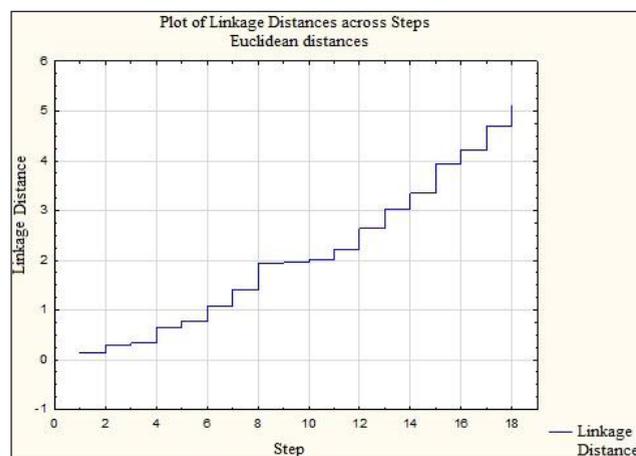
Using the technique of conducting agglomerative hierarchical cluster analysis with the help of the Statistics 10 statistical package, a dendrogram was constructed (Fig. 1). The regions of Ukraine are plotted on the vertical axis, and the inter-cluster Euclidean distances are plotted on the horizontal axis.



Source: Constructed by the authors.

Fig. 1: Dendrogram based on the results of cluster analysis

To determine an optimal number of clusters, a diagram of the step-by-step merging of distances was constructed (Fig. 2). The Euclidean distance is plotted on the vertical axis, and the merging step is plotted on the horizontal axis. We can see that in steps 8 and 15, the largest jump in the distance of merging objects occurs. However, the best solution will be to choose step 15, which allows distinguishing 5 clusters of the regions of Ukraine (the distance of merging objects into clusters is conventionally divided between 3 and 4).



Source: Constructed by the authors.

Fig. 2: Diagram of the step-by-step merging of distances between clusters

As a result of the conducted cluster analysis, it is possible to single out 5 clusters of the regions of Ukraine that suffered similar losses in the functioning of the primary market of residential real estate as a result of the Russian-Ukrainian war (Table 7).

Table 8 presents the average values of the actual and standardized indicators within the clusters of the regions of Ukraine, and Fig. 3 presents a graph of the average values of standardized indicators for each cluster.

Fig. 4 presents a cartogram of the division of the regions of Ukraine into clusters according to the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market.

## DISCUSSION

The war in Ukraine is a big challenge for the real estate market: at its beginning, the market stopped – both construction and sales. Now the situation is slowly recovering, but in general, it is determined by the level of security in the region. The best condition of the real estate market is in the western regions of Ukraine. The declared prices are not supported by the demand and are heated mainly by the expectations of sellers. Mortgage portfolios in the areas close to the hostilities are at significant risk due to the destruction and a decline in borrowers' solvency. According to the report of the National Bank of Ukraine [30], the real estate market is imbalanced, which is confirmed by the research results.

According to the results of the cluster analysis, 5 clusters of the regions of Ukraine were singled out, which suffered similar losses in the functioning of the primary market of residential real estate as a result of the Russian-Ukrainian war. Let the authors characterize these clusters.

Cluster I includes the city of Kyiv, the capital and largest city of Ukraine. In the system of administrative and territorial organization of Ukraine, Kyiv has a special status defined by the Constitution and is not part of any region, although it is the administrative center of the Kyiv region. Despite the losses incurred during the war, Kyiv remains the center of the political, socio-economic, educational, scientific, cultural,

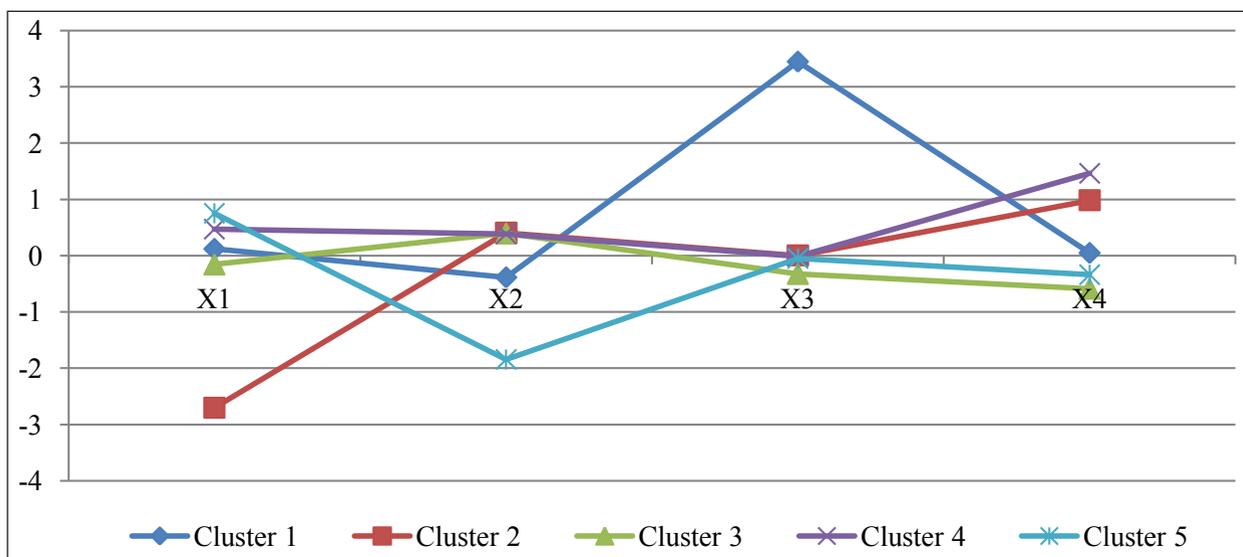
**Table 7:** Distribution of the regions of Ukraine into clusters according to the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Regions with the least impact	Regions with a level of impact below average	Regions with an average level of impact	Regions with a level of impact above average	Regions with the highest level of impact
City of Kyiv	Zakarpattya	Volyn, Zhytomyr, Kirovohrad, Odesa, Ivano-Frankivsk, Khmelnytskyi, Lviv, Ternopyl, Rivne, Chernivtsi	Vinnytsya, Poltava, Dnipropetrovsk, Cherkasy	Zaporizhzhya, Sumy, Chernihiv

**Table 8:** Average values of the indicators within the clusters of the regions of Ukraine

Clusters	Average values of the actual indicators				Average values of the standardized indicators			
	$X_1$	$X_2$	$X_3$	$X_4$	$X_1$	$X_2$	$X_3$	$X_4$
Cluster 1	24.6	-33	85.7	121126	0.121	-0.385	3.447	0.049
Cluster 2	54	-14.9	-42	175429	-2.701	0.405	0.002	0.982
Cluster 3	27.48	-15.09	-54.11	84067.8	-0.156	0.397	-0.325	-0.588
Cluster 4	20.98	-15.35	-42.58	203490.25	0.469	0.385	-0.014	1.465
Cluster 5	18	-66.4	-43.8333	98770.67	0.754	-1.843	-0.048	-0.336

Source: calculated by the authors.

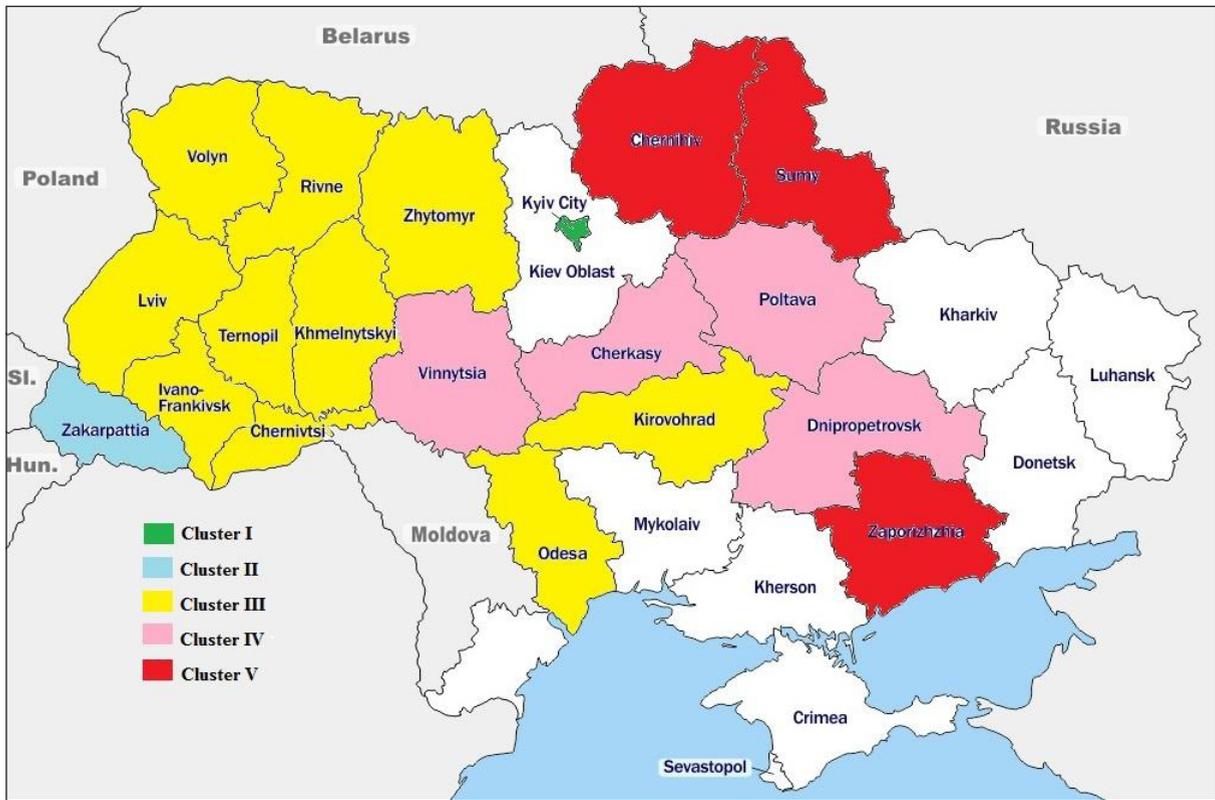


Source: Constructed by the authors.

**Fig. 3:** Average values of the standardized indicators for each cluster

and spiritual life of Ukraine, which makes it attractive to many Ukrainians. The city has a better-organized infrastructure, a more developed business environment, and better logistics, and is a financial center of the country. In the city, there are more opportunities for self-realization, and more chances for residents of the country to find high-paying jobs and get other benefits in living compared to the other cities. That is why, despite the risks, the majority want to settle in Kyiv. In

addition, Kyiv was a leader in residential real estate sales in the pre-war period. The number of new buildings for sale in February 2022 was 221, which was the best result. The second city was Lviv with 216 new buildings, and the third one was Odesa with 172 new buildings. Kyiv is characterized by the highest percentage increase in the area of residential buildings put into operation from January to March 2022 compared to the previous year, 185.7 %. Significant demand and the basing



Source: Constructed by the authors.

**Fig. 4:** Cartogram of the division of the regions of Ukraine into clusters according to the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market

of large construction companies in the city allowed the market to quickly adapt to wartime conditions and continue its activity.

Cluster II includes the Transcarpathian region, which is the westernmost region and is located on the far periphery, which makes it the safest region of Ukraine. Transcarpathia suffered the least during the war. All these factors, as well as a large number of migrants, increased the demand for housing, as a result of which the average price per month per square meter increased by 54 %, which is the highest indicator among all the regions of Ukraine.

Cluster III includes the regions of Ukraine, which are characterized by the average values of the increase in indicators during the war period. These are the regions located in the rear (west and north-west of Ukraine) – Volyn, Zhytomyr, Ivano-Frankivsk, Khmelnytskyi, Lviv, Ternopil, Rivne, Chernivtsi, as well as Odesa and Kirovohrad. These regions did not suffer significant destruction, which allowed companies to resume construction works. A significant share of internally displaced persons was also resettled in these regions.

Cluster IV consists of regions that were significantly affected by the Russian-Ukrainian war. This cluster is also characterized by the average values of the increase in indicators during the war period, however, the largest number of IDPs moved to these regions. The high risk of hostilities deters construction companies from continuing work, and the population is afraid to invest in buying new apartments.

The regions of cluster V suffered the most destruction during the war. These are Zaporizhzhya, Sumy, and Chernihiv. These regions, along with the Donetsk, Luhansk, Kherson, and Mykolaiv regions, as of July 14, 2022, according to the Decree of the Ministry on Reintegration of the Temporarily Occupied Territories of Ukraine, are included in the list of territories located in the areas of military (combat) operations, or which are in temporary occupation, besiegement (blocking). These regions are characterized by high instability of the real estate market and significant deterioration of indicators. This cluster has the highest average level of a decrease in the number of new buildings for

sale, and a critical decrease in the level of demand for residential real estate. The largest decrease in the area of residential buildings put into operation is characteristic of the Sumy region (-73.9 %). The high risk of hostilities near the Zaporizhzhya NPS (the largest in Europe), which increases the fear of a radiation leak is also worth pointing out.

It is worth noting that the research results correlate with the assessments of other researchers, experts, and analysts regarding the changes in the real estate market. According to the report of the National Bank of Ukraine, the demand in the real estate market decreased in all the regions, and the closer to the east, the less it is. For example, if the demand in Lviv decreased by 21 %, in Kharkiv – by 91 %. In the Kyiv region, the indicator fell by almost half – 52 %. Lower demand will be caused by lower income and population emigration, as well as a reduction in mortgages. In the western regions and Kyiv, demand will recover faster due to internal displacement.

## CONCLUSION

The realities of the Russian-Ukrainian war have led to an increase in prices in the primary market of residential real estate, a decrease in the number of new buildings for sale, a decrease in the percentage of the area of residential buildings put into operation compared to the period of the previous year, and a decrease in the number of apartments sold. The real estate market, like other areas of the economy, has experienced significant upheavals. However, as the research showed, each region was affected differently by the consequences of the Russian-Ukrainian war, which allowed the authors to single out 5 clusters of regions based on the level of influence of the Russian-Ukrainian war on the development of the primary residential real estate market using cluster analysis. The heterogeneity in the adaptation of the real estate market to the conditions of military operations and its development during the war should be taken into account by state authorities while:

- ♦ developing strategies for the restoration of territories;
- ♦ optimal distributing funding, which is directed to the reconstruction of destroyed houses or the construction of new ones;

- ♦ establishing and calculating coefficients that will allow receiving accommodation or compensation for it equivalent to the lost one;
- ♦ identifying priority areas for the construction of new housing for internally displaced persons;
- ♦ classifying and taking into account the level of risk when conducting various types of operations, for example, real estate insurance, assistance payments, etc.

Although the war is still ongoing, government support to key sectors of the economy is essential and legislative initiatives in the field of urban planning and new programs of housing rehabilitation should help the residential real estate market to enter a new level of operation during martial law and help further post-war development of the country. The real estate market should be available for the purchase of apartments for displaced or temporarily displaced citizens.

However, the following limitations should be taken into account in this research. First of all, it is assumed that the change in the indicators took place under the influence of the Russian-Ukrainian war and other possible reasons were not taken into account, for example, a change in the legislation that regulates the field of construction, which can affect the number of issued construction permits. Secondly, the work ignores the time lag, since some consequences of the conduct of hostilities can manifest themselves with a delay, for example, a change in the increase of the dollar's rate does not immediately affect the increase in the price of an apartment, since construction companies have stocks purchased in advance at a lower rate, which allows companies not to raise the cost of construction.

As the war is still ongoing, any scenarios of the development of military actions are possible soon, which may have different effects on the direction of the development of the real estate market. Therefore, it is necessary to conduct further research in this field to have relevant results for the current period for making management decisions. In addition, further research should include not only quantitative indicators but also qualitative ones that can have a significant impact on the final result, in particular, such as the quality of housing, the location of a building, natural and climatic conditions, the reputation of the developer, etc.

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