FOREIGN ECONOMIC ACTIVITY AND INVESTMENT POTENTIAL OF UKRAINIAN REGIONS: IDENTIFYING A STABLE CORE AND TERRITORIAL ASYMMETRY WITH MULTIVARIATE CLUSTER ANALYSIS

Purpose. *The purpose of the paper is to perform a comprehensive multidimensional clustering of Ukraine's regions based on a system of indicators reflecting their level of foreign economic activity and investment and entrepreneurial potential. Additionally, the study analyzes the dynamics and stability of their development during 2022–2024 to substantiate a differentiated regional economic policy in the context of the war.*

Methods. *The research relies on official statistical data from the State Statistics Service of Ukraine for the period 2022–2024, thus covering the time since the start of the full-scale war to the present. The input indicators, which include volumes of exports, imports, capital investments, and the number of active enterprises, were standardized using the Z-Score normalization method. For the objective grouping of regions, multivariate cluster analysis (k-means method) was applied. The optimal number of clusters (k=2) was confirmed using the Elbow Method and Silhouette Method, which pointed to a distinct bipolar structure of the economic space.*

Results. *The research findings confirmed the presence of a stable bipolar structure in Ukraine's economic space throughout the entire period under review, indicating profound territorial asymmetry. An unchanging economic core (Cluster 1) was identified, comprising the Dnipropetrovsk, Kyiv, and Lviv Oblasts, which dominate across all key indicators of foreign economic and investment-entrepreneurial activity. Cluster 1 regions demonstrate a high level of integration into international markets and significant investment and production potential. Dnipropetrovsk Oblast maintained its status as an absolute economic outlier, confirming its unique role as an industrial and manufacturing center. The vast majority of oblasts formed Cluster 0, characterized by low to medium levels of economic activity and restricted foreign trade and investment flows.*

Conclusion. *The high stability of the observed asymmetry and the clear typology of regions prove the ineffectiveness of unified approaches in state regional policy. A comprehensive understanding of this regional mosaic is critically necessary for transitioning to differentiated, targeted, and balanced mechanisms of state regulation. These mechanisms should aim to solidify the competitive advantages of the leading regions and strategically stimulate economic activity in the peripheral regions.*

Key words: foreign trade, foreign economic activity, regional development, model, cluster analysis, export, import, investment, economic policy, regional economy, multidimensional analysis, resilience.

JEL classification: F14, F21, R11, R12, C38.

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Introduction. In the context of deepening globalization processes and the systemic integration of Ukraine's national economy into European and global economic structures, regional economic attractiveness acquires strategic significance as a decisive factor in ensuring macroeconomic stability and strengthening national competitiveness. The level of the state's socio-economic development stability is directly dependent on the effective functioning of its regions, their capacity to form stable foreign economic ties, generate export flows, attract significant volumes of capital investment, and create a favorable environment for entrepreneurial activity. Regions serve as the primary hubs of economic activity where production, labor, and investment resources are concentrated. Foreign trade activity and investment and entrepreneurial potential are the key components that comprehensively secure regional development and integration into the global economy. However, Ukraine's economic space is characterized by significant asymmetry and territorial differentiation, demanding the development of flexible and targeted

mechanisms for state regulation. A comprehensive understanding of this regional mosaic, based on the objective classification of oblasts according to their economic capabilities, is a necessary prerequisite for forming an effective, balanced, and socially oriented economic policy.

The aim of this article is to perform a comprehensive clustering of Ukraine's oblasts based on an integrated system of indicators reflecting their level of foreign economic competitiveness and investment and entrepreneurial potential, and to analyze their development dynamics from 2022 to 2024 for the purpose of formulating effective regional economic policy.

Literature review. The key theoretical pillar of this research is the role of foreign trade and investment as drivers of economic development that shape the regional economic core. The international literature confirms that foreign trade and foreign direct investment have positive spillover effects on economic growth and contribute to sustainable development (Zamani & Tayebi, 2022; Liu et al., 2024). However, the impact may be nonlinear, as evidenced by studies on threshold effects, particularly concerning carbon emissions (Derindag et al., 2023; Liu et al., 2024). The impact of trade also extends to social aspects: authors used econometric models to examine the link between foreign trade and inclusive growth and income inequality (Oladapo and Oyaromade, 2025) and (Takım and Gültekin, 2022). At the level of regional blocs, the research on BRICS countries confirms that economic integration can reinforce foreign trade (Adda et al. 2025), providing an important precedent for Ukraine's European integration efforts. Nevertheless, question whether foreign trade limits the growth of peripheral regions, a point directly relevant to the "core–periphery" concept identified in the current analysis (Atienza Montero and Hierro Recio, 2025).

Analyzing the regional dimension of foreign trade and competitiveness requires identifying factors that contribute to the formation of the economic core. Authors identified a complex set of economic, institutional, and environmental drivers of foreign trade (Kubatko et al. 2024), while others highlighted the synergistic effect of education, innovation performance, and foreign trade on economic indicators (Aysan et al., 2021). Methodologically, the current research resonates with studies that use quantitative methods for regional trade analysis, including gravity models (Ayala et al., 2021; Demirci & Sevüktekin, 2022), spatial econometrics for assessing trade elasticity (Zofio et al., 2025), Bayesian model (Najafi et.al, 2024), panel VAR approach (Kacou et.al, 2022) and Granger causality (Feng, 2022). Works further illustrate how specialized instruments (such as foreign trade zones) and advanced forecasting methods can be applied to manage and stimulate regional foreign economic activity (Han et al., 2022; Lane & Liu, 2022).

Contemporary economic studies on Ukraine focus on understanding regional resilience and structural disparities in the face of external shocks, particularly following the pandemic and amidst the full-scale war. The research analyzing Ukraine's services export, revealed critical shifts in foreign economic resilience caused by these crises (Vdovyn and Zomchak, 2022). This context of structural changes is complemente to a structural model reflecting key interactions between GDP and industrial output, confirming fundamental economic dependencies (Zomchak and Miskiv, 2024). The issue of regional inequality is particularly acute: (Zomchak and Hakava, 2025), using a multidimensional ranking approach, identified significant disparities and resilience levels in regional labor markets, which correlates with the bipolar economic structure concept found in the current study. A deeper understanding of external threats is provided by (Vdovyn, 2025), who analyzed Ukraine's position in the Fragile States Index through the lens of conflict and threats, forming the overall backdrop for assessing regional economic attractiveness. International links are also highlighted in the study (Orudzhev and Alizade, 2021), who analyzed the impact of GDP on trade turnover between Ukraine and Azerbaijan.

Foreign Economic Activity of Ukrainian Regional Development: Data, Indicators and Methodology. The informational basis for this research is formed using official statistical collections and databases from the State Statistics Service of Ukraine for the period 2022–2024. The application of multivariate statistical analysis allows for the objective grouping of regions based on the degree of similarity in their economic characteristics.

The assessment of regions' foreign trade activity is conducted using export and import indicators, which serve as key indicators of foreign economic competitiveness and the openness of the regional economy.

Goods export (thous. USD) is utilized as an indicator of foreign economic competitiveness and the region's ability to generate foreign currency revenue. The highest volume of exports was recorded in

the Lviv Oblast (2,711,819.5 thous. USD), followed by Vinnytsia and Odesa Oblasts. This leadership indicates the high adaptability of these regions' economies to international market demands and the effective use of existing logistics corridors. In contrast, export volumes in the Luhansk and Donetsk Oblasts are minimal, a direct consequence of the ongoing impact of military actions on their production and logistics infrastructure.

Goods import (thous. USD) characterizes the region's need for external resources (raw materials, equipment, technologies) and indirectly reflects the market's consumption capacity, demonstrating different centers of gravity. The largest volumes of imports were recorded in Kyiv City (3,329,368.6 thous. USD) and Odesa Oblast (2,792,329.9 thous. USD). These figures underscore their critically important role as key logistics, distribution, and financial hubs of the country. High imports may indicate both strong investment demand for high-tech equipment and a significant volume of final consumption, which is typical for the capital.

The evaluation of internal economic potential is based on three key indicators characterizing the entrepreneurial environment and investment activity: total number of active enter, volume of products (goods, services) sold by enterprises and capital investment.

Total number of active enterprises is a key indicator of entrepreneurial activity and the saturation of the regional market with business entities. The leader in this indicator is Dnipropetrovsk Oblast (50,978 units), pointing to a powerful, diversified, and deeply rooted business sector. High enterprise concentration is also demonstrated by Lviv, Odesa Oblasts, and Kyiv City, confirming their status as major economic centers capable of generating significant internal competition and innovation.

Volume of products (goods, services) sold by enterprises (thous. UAH) acts as an integral measure of the region's economic potential and scale of production. The absolute dominance here belongs to Kyiv City (680,363,701.45 thous. UAH), which is expected given the concentration of headquarters, financial, and service companies. However, among manufacturing regions, the highest sales volume belongs to Dnipropetrovsk Oblast (1,667,492,954.8 thous. UAH), unequivocally confirming its status as a powerful industrial and manufacturing core of the country.

Capital investment (thous. UAH) determines the region's investment attractiveness and its ability to attract resources for fixed asset renewal and long-term development. This indicator is also led by Kyiv City (2,568,459,07 thous. UAH), reflecting the largest concentration of investment projects and financial resources. Following the capital are Odesa and Lviv Oblasts. The relatively high volumes of capital investment in these regions attest to their resilience, investment appeal, and business expectations for positive long-term development, which is closely correlated with their high foreign trade activity.

In summary, the analysis of absolute indicators for 2024 reveals a group of distinct regional leaders (Kyiv City, Dnipropetrovsk, Lviv, Odesa, Vinnytsia) that dominate across all key economic criteria. At the same time, significant differences in their profiles are observed (e.g., Kyiv as a service center versus Dnipropetrovsk as a manufacturing core). This confirms the expediency of applying multivariate clustering methods for the objective grouping of oblasts with similar, but not identical, economic activity profiles.

The procedure for clustering Ukraine's oblasts was conducted in stages, including data preparation, determining the optimal number of groups, and final grouping.

Since the input indicators (export, import, capital investment) have different scales, units of measurement, and significant discrepancies in absolute values, data standardization was performed to ensure their comparability and avoid the dominance of indicators with the largest absolute values. Each indicator was transformed using the Z-Score normalization method (standardization), which brings all data to a dimensionless scale with a mean of zero and a unit standard deviation.

To substantiate the optimal number of clusters, two key empirical methods were applied:

1. Elbow Method: This method was used to analyze the sum of squared distances (inertia) from points to their cluster centers. The "elbow" point on the graph, where the decrease in inertia becomes least significant, indicated the most likely number of clusters (figure 1).
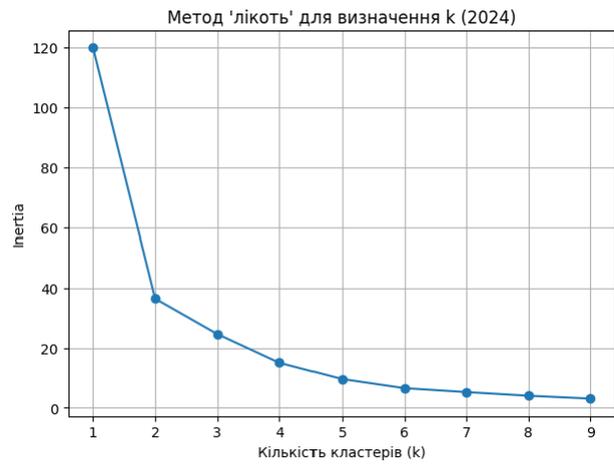
2. Silhouette Method: This method was used to assess the density and separability of the clusters. A high silhouette coefficient indicates how similar an object is to its own cluster compared to other clusters, thereby confirming the optimality of the chosen number k (figure 2).

Based on the analysis of the graphs from both methods, which visually confirmed the presence of a clear bipolar structure, the optimal number of clusters was empirically established as k=2.
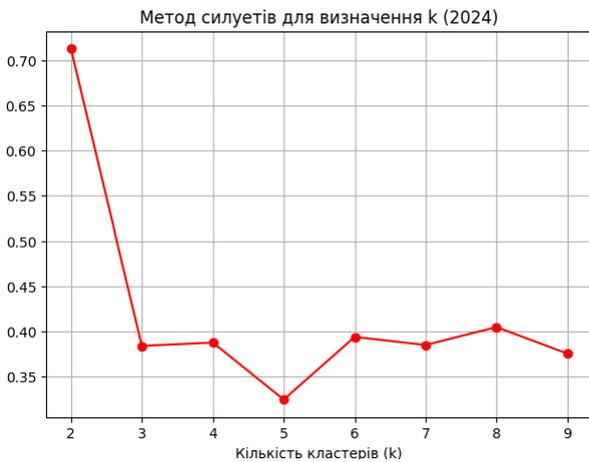
Fig. 1. Elbow method
Sources: calculated by authors

Fig. 2. Silhouette Method
Sources: calculated by authors

The non-hierarchical k-means method was used for the final and accurate distribution of regions into the two specified groups. This method minimizes the sum of squared distances from each region to the center (centroid) of its cluster, ensuring maximum intra-cluster homogeneity.

After the final distribution of regions, the Euclidean distance to the centroid of its cluster in the multi-dimensional space of standardized features was calculated for each region. This distance serves as an important criterion for assessing the representativeness of each region within its cluster: the smaller the distance, the closer the region is to the "ideal" profile of its group.

The entire clustering procedure was conducted separately for each year (2022, 2023, 2024), allowing for tracking the migration dynamics of regions between clusters and assessing the stability of their economic position amidst significant external shocks. To ensure the correctness of the analysis results and avoid statistical distortions, Kyiv City was excluded from the sample due to the substantial excess of its economic indicators over corresponding values in other regions, which could have led to distortion of the clustering results and reduced its analytical validity.

Empirical Results and Analysis of Regional Asymmetry in Ukraine: A Cluster Approach to Foreign Trade and Investment Potential for Core-Periphery Identification. In 2022, the structure of the regions' economy already demonstrated a bipolar configuration, although at the initial stage of the economic system's destabilization, it was less pronounced than in subsequent years.

Cluster 0 included the vast majority of oblasts with a medium level of economic activity. This cluster united regions with diverse economic profiles: agrarian, industrial-agrarian, and transit. For example, Odesa Oblast, despite high logistical potential, did not enter the cluster of leaders due to low integral activity indicators, limited export volumes, and moderate investment flows. Cluster 0 was characterized by limited foreign trade and investment activity, moderate scales of entrepreneurial activity, and capital investment. The most typical region of Cluster 0 was Khmelnytskyi Oblast with a Euclidean distance to the centroid of 0.3177, indicating that its economic profile was maximally close to the group's average indicator.

Cluster 1 formed the economic core of the country and consisted of Dnipropetrovsk, Kyiv, and Lviv Oblasts. Lviv Oblast immediately entered this cluster due to its logistical and transit advantages, which were critically important at the beginning of the crisis period. Dnipropetrovsk Oblast remained an absolute economic outlier with a Euclidean distance of 2.5319, demonstrating a unique industrial profile with a high concentration of industrial production, entrepreneurial activity, and capital investment. Cluster 1 was characterized by a high level of integration into international markets, significant volumes of export and realized products, and stable investment appeal, forming a clearly defined economic core of the country.

In terms of dynamics, it was observed that most regions in Cluster 0 remained stably peripheral, while regions with development potential (western and central oblasts) were already beginning to approach the Cluster 1 centroid. This situation laid the foundation for further regional differentiation in the following years.

In 2023, the bipolar structure of Ukraine's economy was preserved and became more pronounced.

Cluster 0 remained the largest in terms of number and united regions with low or medium economic activity. It included oblasts with diverse economic profiles but united by a low level of foreign trade and investment activity, moderate volumes of capital investment, and entrepreneurial activity. Khmelnytskyi Oblast again remained the typical region, its Euclidean distance to the Cluster 0 centroid being 0.2947, indicating proximity of the economic profile to the cluster's average activity.

Cluster 1 consisted of the leading regions: Dnipropetrovsk, Kyiv, and Lviv Oblasts. Lviv Oblast strengthened its role as a Western logistics and investment hub, with a Euclidean distance to the centroid of 1.0747, underscoring its intermediate position among the leaders. Dnipropetrovsk Oblast remained an absolute economic outlier with a distance of 2.2074, confirming its uniqueness and concentration of production potential. Cluster 1 was distinguished by a high level of integration into international markets, stability of investment appeal, and significant volume of production activity.

In 2023, an intensification of structural differentiation was observed: the peripheral regions of Cluster 0 remained relatively homogeneous, while regions with economic potential increasingly approached the Cluster 1 centroid, indicating the growing influence of the Western logistical-investment segment.

In 2024, the bipolar structure of Ukraine's economy was confirmed as stable and clear.

Cluster 0 remained the largest in terms of the number of regions and included oblasts with a medium or low level of economic activity, as well as regions whose economic activity was limited by military actions. The cluster was characterized by limited volumes of foreign trade and investment activity, moderate scales of entrepreneurial activity, and capital investment. Structurally, Cluster 0 remained heterogeneous, combining agrarian, industrial-agrarian, and transit regions that significantly lagged behind the economic leaders. The most typical region remained Mykolaiv Oblast with a Euclidean distance of 0.2872.

Cluster 1 united Dnipropetrovsk, Kyiv, and Lviv Oblasts, forming the country's economic core. Dnipropetrovsk Oblast remained an absolute economic outlier with a Euclidean distance of 2.5319, confirming its unique industrial profile and significant concentration of production and entrepreneurial activity. The regions in Cluster 1 were characterized by high integration into international markets, stable investment appeal, and significant production potential. This structure confirms the existence of a stable economic core and a significant asymmetry between the leading and peripheral regions.

The analysis of data for 2022–2024 demonstrates the high stability of the bipolar structure of Ukraine's economy. The economic core, formed by the Dnipropetrovsk, Kyiv, and Lviv Oblasts, remained unchanged throughout the entire period, underscoring their fundamental status as centers of production, logistics, and investment. Dnipropetrovsk Oblast maintained its status as an absolute economic outlier for all three years, demonstrating a unique industrial profile, high concentration of production activity, and entrepreneurial potential.

The peripheral regions of Cluster 0 remained relatively homogeneous and economically weaker, although certain western and central oblasts demonstrated a gradual approach to the Cluster 1 centroid, indicating a slow increase in their economic potential. Overall, the clustering dynamics confirm a stable demarcation of centers and periphery, the existence of a stable economic core, and the gradual intensification of asymmetry between the leading and weaker regions of the country, which is of critical importance for forming differentiated regional development strategies.

Conclusions. The conducted research on the regional economic attractiveness of Ukraine for 2022–2024 allowed for the assessment of the dynamics of oblast development, their integration into international markets, and their investment and entrepreneurial potential. Based on multivariate cluster analysis, structural patterns of the country's economic space were determined, enabling substantiated conclusions regarding the typology of regions and the effectiveness of state regional policy.

The multivariate cluster analysis (k-means method with $k=2$) confirmed the existence of a stable bipolar structure of Ukraine's economic space throughout the entire period of study. This structure clearly divides the regions into two classes: the economic core and the periphery, indicating a deep and intensifying territorial asymmetry.

The unchanging economic core of the country (Cluster 1), formed by the Dnipropetrovsk, Kyiv, and Lviv Oblasts, was identified. These regions dominate across all key integral indicators (export, import, capital investment, number of enterprises) and demonstrate a high level of integration into international markets, as well as significant investment and production potential. Dnipropetrovsk Oblast maintained

its status as an absolute economic outlier for three years, confirming its unique role as an industrial and manufacturing center.

The vast majority of oblasts were included in Cluster 0. This cluster is heterogeneous in profile (agrarian, transit) but homogeneous in its low or medium level of economic activity and limited volumes of foreign trade and investment activity compared to the leading regions. This confirms that most oblasts are characterized by significantly lower resilience to external shocks and a weaker ability to generate stable economic flows.

The established stability of the asymmetry and the clear typologization of regions according to their economic profiles prove the ineffectiveness of unified approaches in state regional policy. A comprehensive understanding of this regional mosaic is a necessary prerequisite for transitioning to differentiated, targeted, and balanced mechanisms of state regulation. Policy should be aimed at consolidating the competitive advantages of the leading regions and the targeted stimulation of investment and entrepreneurial activity in the peripheral regions to reduce inter-regional disparities.

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ЗОВНІШНЬОЕКОНОМІЧНА АКТИВНІСТЬ ТА ІНВЕСТИЦІЙНИЙ ПОТЕНЦІАЛ РЕГІОНІВ УКРАЇНИ: ІДЕНТИФІКАЦІЯ СТІЙКОГО ЯДРА ТА ТЕРИТОРІАЛЬНОЇ АСИМЕТРІЇ МЕТОДАМИ БАГАТОВИМІРНОЇ КЛАСТЕРИЗАЦІЇ

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Метою *статті є здійснення комплексної багатовимірної кластеризації областей України на основі інтегральної системи показників, що відображають їхній рівень зовнішньоекономічної конкурентоспроможності та інвестиційно-підприємницького потенціалу, а також аналіз динаміки та стійкості їхнього розвитку впродовж 2022–2024 років для обґрунтування диференційованої регіональної економічної політики в умовах війни. У контексті інтеграції України у світову економіку розуміння регіональних диспропорцій є важливим для формування ефективної регіональної політики та підвищення національної конкурентоспроможності.*

Методи. *Дослідження базується на офіційних статистичних даних Державної служби статистики України за період 2022–2024 рр., тобто охоплює період від початку повномасштабної війни і дотепер. Вхідні показники, що включають обсяги експорту, імпорту, капітальних інвестицій та кількість активних підприємств, були стандартизовані методом Z-Score нормалізації. Для об'єктивного групування регіонів застосовано багатовимірний кластерний аналіз (метод k-середніх). Оптимальна кількість кластерів (**k=2**) підтверджена за допомогою методів «ліктя» та «силуетів», що вказали на чітку біполярну структуру економічного простору.*

Результати. *Результати дослідження підтвердили наявність стійкої біполярної структури економічного простору України впродовж усього досліджуваного періоду, що свідчить про глибоку територіальну асиметрію. Ідентифіковано незмінне економічне ядро (Кластер 1), сформоване Дніпропетровською, Київською та Львівською областями, які домінують за всіма ключовими показниками зовнішньоекономічної та інвестиційно-підприємницької активності. Регіони Кластера 1 демонструють високий рівень інтеграції у міжнародні ринки та значний інвестиційно-виробничий потенціал. Дніпропетровська область зберігала статус абсолютного економічного лідера, підтверджуючи свою унікальну роль індустріально-виробничого центру. Переважна більшість областей увійшла до Кластера 0 (Периферія), який характеризується низьким/*

середнім рівнем економічної активності та обмеженими зовнішньоторговельними та інвестиційними потоками. Периферійні регіони залишаються економічно слабшими, хоча деякі західні та центральні області поступово наближаються до ядра.

***Висновки.** Виявлена висока стійкість асиметрії та чітка типологізація регіонів доводить неефективність уніфікованих підходів у державній регіональній політиці. Комплексне розуміння цієї регіональної мозаїки є критично необхідним для переходу до диференційованих, адресних та збалансованих механізмів державного регулювання, спрямованих на закріплення конкурентних переваг регіонів-лідерів та цільове стимулювання економічної активності в регіонах-периферії. Результати дослідження дають змогу обґрунтовано формувати стратегії, спрямовані на зміцнення економічного ядра та стимулювання розвитку периферійних регіонів, що підвищує загальну економічну стійкість та конкурентоспроможність країни.*

Ключові слова: зовнішня торгівля, зовнішньоекономічна діяльність, регіональний розвиток, модель, кластерний аналіз, експорт, імпорт, економічна політика, регіональна економіка, багатовимірний аналіз, резильєнтність.