INTEGRAL EVALUATION OF ECONOMIC COMPONENT OF SPATIAL DEVELOPMENT DIVERSIFICATION IN UKRAINIAN REGIONS

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Abstract: *Diversification is generally considered to reduce the risks of undesirable developments, particularly in the face of external challenges and shocks. Diversification of spatial development is a complex phenomenon that encompasses various spheres of the socio-economic development of a country's regions. This study is devoted to the quantitative measurement of the diversification of the economic component of spatial development at the regional level. The aim of the article is to assess changes in the diversification of spatial development in the regions of Ukraine caused by military aggression.*
The study employs methods of multivariate analysis, namely factor analysis (principal component analysis with rotation), the method of information space aggregation (integral indicator), and the Herfindahl–Hirschman Index. The integral assessment of the level of diversification of spatial development in Ukraine's regions is carried out based on components of the economic dimension, using indicators that describe budget structure, export activity, sectoral structure, capital investment, employment, business environment, and innovation, which were applied to analyze the geographical and sectoral dimensions of economic diversification.
The integral assessment of diversification of spatial development in the regions of Ukraine made it possible to identify key diversification factors: budgetary, sectoral, tax, employment, scientific, investment and innovation, economic activity, and innovation-related factors, the composition of which changed during wartime compared to the pre-war period. The most diversified regions in terms of the economic component in 2021 and 2023 were identified, and three groups of regions of Ukraine were distinguished according to the level of diversification based on the value of the calculated integral indicator. During the analyzed period, changes in the values of the integral diversification indicator occurred in all regions; however, it was found that the overall ranking of regions remained largely stable.
The application of the developed approach to assessing the level of diversification of spatial development in the regions of Ukraine will make it possible to determine the most influential diversification factors, identify disparities in diversification across different components and dimensions of spatial development, and ensure a faster response to emerging threats, in particular by identifying directions for adjusting regional-level strategies and programs.

Key words: *diversification, spatial development, integral indicator, factor analysis, region.*

JEL: C02; R12

Introduction

Diversification is generally considered to reduce the risks of undesirable developments, particularly in the face of external challenges and shocks. Diversification of spatial development is a complex phenomenon that encompasses various spheres of the socio-economic development of a country's regions.

Diversification of spatial development of regions implies the development of territories within a state, taking into account their specific natural, economic, cultural, and social characteristics. It contributes

to the balanced development of all regions of the country, the reduction of territorial disparities and inequalities, as well as the fuller realization of each territory's potential.

In scientific research, various approaches [1–5] are distinguished for defining spatial development and its role in shaping socio-economic processes across different types of territories. Within the framework of this study, the approach to interpreting the diversification of spatial development of regions proposed by Yu. Ivanov, O. Ivanova is applied, viewing it as a process of ensuring stable socio-economic development of territorial units, creating conditions for their self-sufficiency and self-development, improving the efficiency of the use of regional-level resources, eliminating regional disparities and dependence on the center, and reducing budgetary and financial risks at the meso level [6].

An integral assessment of the diversification of spatial development of the regions of Ukraine is a necessary stage of the empirical analysis of economic diversification in the country's spatial development. It involves the application of an evaluation methodology that takes into account the interrelationships between socio-economic indicators, avoids their duplication, and provides a comprehensive view of the results.

The aim of this study is to assess changes in the level of diversification of spatial development in Ukraine's regions caused by military aggression.

Only a limited number of studies are devoted to measuring the level of economic diversification as a whole. The Herfindahl–Hirschman Index and its modifications are most commonly used. The greatest attention is paid to diversification in the context of international trade.

The United Nations Conference on Trade and Development (UNCTAD) measures indices that are inverse to diversification – namely, concentration indices of commodity exports and imports for each country, based on the share of a specific commodity (or group of commodities) in the total volume of a country's exports (imports), as well as market concentration indices for particular goods relative to their countries of origin. In this context, the Theil index [7], the Herfindahl–Hirschman Index [8], and the Gini coefficient are used.

The diversification of public revenues is assessed based on the shares of excise taxes, corporate income tax, taxes on goods and services, as well as total revenues as a percentage of GDP [9].

The most generalized approach to assessing the level of diversification is proposed in an experimental project [10], which introduces the Global Economic Diversification Index (EDI) for countries worldwide. The index covers three areas: output, trade (international), and revenues (public). While specific types of economic activity are not examined in detail, the output sub-index distinguishes agriculture, extractive industries, manufacturing, and medium- and high-technology industries. A distinctive feature of the project is its focus on analyzing resource dependence of economies; therefore, resource rents and exports of hydrocarbons and fuels are also included in the analysis.

Trade diversification is assessed using gross export and import volumes, the share of exports of manufactured goods and medium- and high-technology industries, as well as export and import concentration indices calculated by the World Bank and UNCTAD [10]. The primary data for evaluating all components are sourced from the World Bank, UNCTAD, and the International Monetary Fund, which ensures consistency in measurement.

Unlike most other studies, the diversification index is constructed based on the identification of principal components, which makes it possible to combine indicators of different origins. At the same time, the assessment results for different years are not directly comparable, since the weighting coefficients for each year (taking into account their dynamics and the increasing number of countries covered during 2019–2022) differ; however, the relative ranking of countries is preserved.

The Principal Components Analysis, a standard dimensionality-reduction technique, was used to generate the results. The strategy for applying PCA to the detailed indicators relied on two steps. The first was to use PCA to produce the three sub-indices: output, trade, and revenue. The second was then to aggregate the three subindices into an overall EDI by taking the arithmetic (simple) mean [10].

Among the advantages of the proposed index for assessing the diversification of a country's spatial development is its coverage not only of the production and external economic spheres, but also of the fiscal (budgetary) domain. In addition, the approach involves constructing a composite indicator, which makes it possible to rank objects and simplifies analysis. The use of principal components as estimates for sub-indices can also be applied, although it requires more thorough justification. At the same time, the principal component method can be used to identify the most influential indicators for constructing an assessment of the level of diversification. These advantages determined the choice to apply the principal component method and linear aggregation to assess the economic component of the diversification of spatial development in the regions of Ukraine.

Basic content

Figure 1 presents an algorithmic model for calculating the integral indicator of diversification of spatial development in the regions of Ukraine, which consists of three steps. The initial data for conducting the integral assessment are partial indicators of diversification by components and subcomponents. At this stage of the study, the economic component was considered.

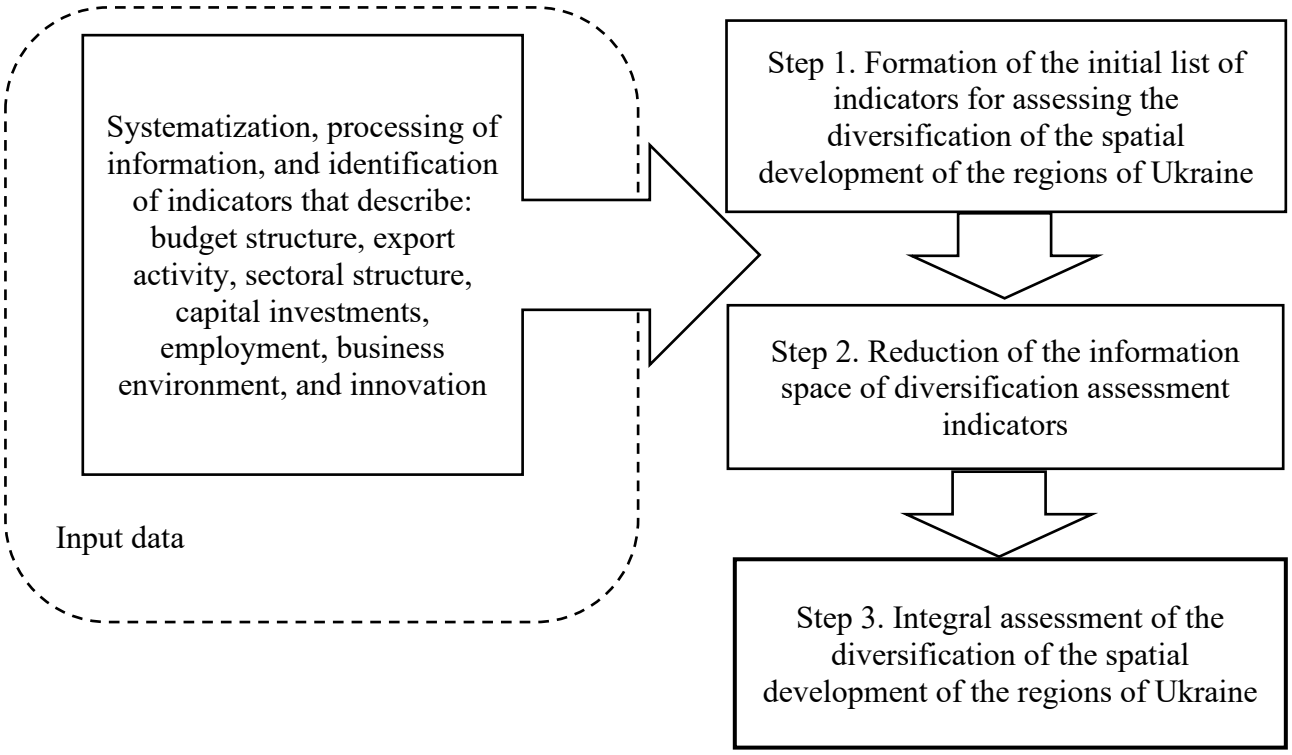

Figure 1. Algorithmic model of the integral assessment of the diversification of the spatial development of the regions of Ukraine

Source: compiled by the authors

Step 1. *Formation of the initial list of indicators for assessing the diversification of the spatial development of the regions of Ukraine.* Based on a synthesis of the scientific literature and the developments of international organizations [2, 4, 6-8, 10], an initial list of indicators that can potentially characterize the level of diversification of spatial development was formed. To construct the information and analytical framework of the study, a set of indicators describing the budget structure, export activity, sectoral structure, capital investments, employment, business environment, and innovation was identified. These indicators were used to analyze the geographical and sectoral dimensions of economic diversification according to data from [11,12].

For further calculations, data processing, systematization, and selection of indicators for analysis were carried out. The list and notation of the indicators for assessing the diversification of spatial development, initially selected for calculating the integral index, are presented in Table 1.

Table 1. Indicators for assessing the diversification of the spatial development of Ukraine's regions by the economic component

№	Indicator name	Indicator notation
1	Herfindahl–Hirschman Index of the structure of local budget revenues	HHI_budg_rev
2	Herfindahl–Hirschman Index of the structure of tax revenues to local budgets	HHI_tax_rev
3	Total revenues per 1,000 persons, thsd. UAH	Budg_rev_pc
4	Total own revenues per capita, UAH	SBudg_rev_pc
5	Herfindahl–Hirschman Index by export commodity groups	HHI_Exp
6	Herfindahl–Hirschman Index of the distribution of sales volumes across 27 types of economic activity	HHI_OR_27
7	Share of the manufacturing industry in total sales volume	ShMan
8	Herfindahl–Hirschman Index based on the shares of types of economic activity in the region's gross value added	HHI_VA
9	Economic productivity, %	VA_p_Output
10	Labor productivity of employed persons	Prod_emp
11	Herfindahl–Hirschman Index of capital investments by types of economic activity	HHI_inv
12	Capital investment intensity, UAH per 1,000 UAH of gross value added	Inv_intens
13	Share of large enterprises in total employment, %	LE_emp
14	Herfindahl–Hirschman Index by the number of employed persons across 16 types of economic activity	HHI_emp_18
15	Informally employed population as a percentage of the total employed population aged 15–70 in the region	Inform_emp
16	Herfindahl–Hirschman Index of the distribution of the number of business entities across 27 types of economic activity	HHI_En_27
17	Share of large enterprises in the total number of active enterprises	LE_sh
18	Share of small enterprises in the total number of active enterprises	SE_sh
19	Number of applications for patents for inventions, utility models, and industrial designs per 100,000 population	IPZ
20	Number of registered intellectual property titles per 100,000 population	IPR
21	Share of innovation-active enterprises in the total number of enterprises in the region, %	InAE
22	Innovation expenditures as a percentage of the region's capital investments, %	InVytr
23	Number of elements of the innovation infrastructure	In_infr

Source: compiled by the authors

In accordance with the purpose of the study, 2021 was chosen as the base year. For the current assessment of the diversification of the spatial development of the regions of Ukraine, input data for 2023 were used as the most complete. Thus, the initial information space included two sets of available data. It should be noted that, due to confidentiality reasons as well as the unreliability of data for the Donetsk and Luhansk regions, certain indicators were not calculated, which subsequently led to the exclusion of these regions from the overall diversification ranking. This also applies to two additional regions, as will be shown below.

Step 2. *Reduction of the information space of diversification assessment indicators.* The reduction of the list of input indicators was carried out using factor analysis. Since the indicators used to assess diversification have different units of measurement, a standardization procedure was applied in the

study. The use of the principal component method with rotation made it possible to identify the most influential factors among the initially selected indicators.
Unlike study [10], in which, according to the division into three components, all indicators of the respective component were included in the factors regardless of their factor loadings, in our study only statistically significant indicators were included in the factors. This made it possible to identify specific directions of diversification, which can subsequently serve to determine priorities. The application of the selected methodological tools allowed for a reduction of the initial data space and the identification of the following most significant factors for assessing the diversification of the spatial development of the regions of Ukraine in 2021:

F1 (budgetary) = - 0,929828*HHI_budg_rev - 0,722743*HHI_tax_rev +
+ 0,829546 * Budg_rev_pc + 0,909474*SBudg_rev_pc - 0,729228*HHI_En_27;
F2 (sectoral) = 0,759573*HHI_Exp + 0,804813*ShMan -0,904363*VA_p_Output +
+ 0,893535*LE_emp+0,779614*LE_sh;
F3 (scientific) = 0,865267* IPZ+0,859689*IPR;
F4 (investment-innovation) = 0,744431* Inv_intens - 0,847315*SE_sh;
F5 (economic activity) = 0,811522 * HHI_VA + 0,784770 * HHI_emp;
F6 (innovative) = 0,705338*InAE.

As a result of reducing the information space of diversification assessment indicators by regions for 2023, as in the base year 2021, the following factors were obtained using factor analysis:

F1 (budgetary) = 0,857*Budg_rev + 0,8819* SBudg_rev_pc -0,8149*HHI_En_27;
F2 (sectoral) = - 0,821*HHI_OR_27 + 0,8114*ShMan + 0,893*HHI_inv;
F3 (tax) = 0,8649* HHI_budg_rev + 0,9526*HHI_tax_rev;
F4 (employment) = 0,7545* Prod_emp + 0,7737*LE_emp + 0,9218*LE_sh;
F5 (innovation expenditure) = 0,9114* InVytr ;
F6 (innovation infrastructure) = 0,9275* In_infr.

Thus, in 2023, compared to 2021, changes occurred in the composition of factors identified for assessing the diversification of the spatial development of Ukraine's regions. There was a reduction in the number of indicators reflecting the budgetary and sectoral structure. However, a tax-related factor, an employment factor, as well as separate factors of innovation expenditures and innovation infrastructure were identified. This indicates the dynamic nature of the environment, the need for rapid adaptation to the challenges of regional development in Ukraine due to the emergence of new threats, as well as the necessity to adjust strategies or make appropriate managerial decisions.

Step 3. *Integral assessment of the diversification of the spatial development of the regions of Ukraine.*
At the final stage of the study, the reduction of the information space is carried out using an integral indicator that combines the factors obtained in the second step of the algorithmic model for assessing the diversification of spatial development of Ukraine's regions. This indicator makes it possible to quantitatively measure an object described by a large number of variables by aggregating them into a single composite measure, and also enables the ranking of the objects under study.
To calculate the integral indicator of diversification of spatial development of the regions of Ukraine, an additive model is used:

ID (Integral indicator of diversification) = $(F_1 + \ldots + F_n)/n$, (1)

$(F_1 \ldots F_n)$ – values of the factors;
n – number of factors.

The justification for using the simple average lies in the fact that it is the most transparent approach, while there are no a priori grounds to assume that any of the selected factors is more important for the overall measurement of economic diversification than others. Table 2 presents the calculated values of the integral indicator of diversification by regions in 2021. The ranking of Ukraine's regions

is based on the ID, assuming that higher values of the integral indicator correspond to more diversified regions.

Table 2. Integral indicator of diversification for the regions of Ukraine, 2021

Region	Factors						ID	Region's rank by ID
	F1	F2	F3	F4	F5	F6		
Vinnytsia	-0,40	0,38	0,11	0,29	0,99	1,74	0,52	3
Volyn	x	x	x	x	x	x	x	x
Dnipropetrovsk	1,30	1,41	0,46	-0,43	0,97	0,69	0,73	2
Donetsk	-1,20	2,95	-1,36	0,45	-0,07	-1,24	-0,08	12
Zhytomyr	0,02	-0,81	-0,46	0,36	-0,80	-1,22	-0,48	19
Zakarpattia	x	x	x	x	x	x	x	x
Zaporizhzhia	-0,03	1,83	1,67	-1,00	-0,70	-0,93	0,14	8
Ivano-Frankivsk	-0,85	0,15	0,40	-1,49	-0,25	0,29	-0,29	16
Kyiv	1,53	0,20	-0,26	1,09	-1,27	0,46	0,29	5
Kirovohrad	0,70	-0,84	-0,37	-0,49	0,96	-0,80	-0,14	14
Luhansk	-2,04	-0,49	-0,67	0,94	-0,45	-1,16	-0,65	21
Lviv	0,70	-0,41	-0,51	-0,08	-1,93	0,21	-0,34	17
Mykolaiv	0,07	0,46	-0,62	-1,97	0,16	1,33	-0,10	13
Odesa	0,97	-0,37	-0,78	-1,25	-1,22	0,58	-0,34	17
Poltava	1,55	-0,06	0,68	0,45	2,15	-1,80	0,49	4
Rivne	-1,20	-0,32	-0,02	-0,06	-0,40	0,77	-0,20	15
Sumy	-0,21	-0,31	0,18	1,63	-0,50	0,00	0,13	9
Ternopil	-1,18	-0,13	2,07	1,37	0,81	1,74	0,78	1
Kharkiv	0,66	-0,72	2,40	0,16	-1,30	-0,78	0,07	10
Kherson	-0,33	-0,88	-0,22	-1,02	1,23	-0,91	-0,36	18
Khmelnytskyi	-0,36	-0,22	-0,60	0,64	0,51	0,20	0,03	11
Cherkasy	0,45	0,36	-0,39	0,66	-0,04	0,28	0,22	7
Chernivtsi	-1,18	-1,63	-0,03	-1,29	0,45	-0,27	-0,66	20
Chernihiv	1,02	-0,54	-1,67	1,04	0,71	0,82	0,23	6

Note. Regions marked with "x" were not included in the calculations due to a lack of data. The same applies to the following tables
Source: compiled by the authors

Further, to examine the diversification of the regions of Ukraine over time, the integral indicator of diversification for the regions in 2023 was calculated (Table 3).

Table 3. Integral indicator of diversification for the regions of Ukraine, 2023

Region	Factors						ID	Region's rank by ID
	F1	F2	F3	F4	F5	F6		
1	2	3	4	5	6	7	8	9
Vinnytsia	x	x	x	x	x	x	x	x
Volyn	-1,14	-1,38	1,44	1,66	-0,18	-0,42	-0,005	10
Dnipropetrovsk	1,40	0,88	-0,35	1,75	0,35	-0,02	0,67	1
Donetsk	x	x	x	x	x	x	x	x
Zhytomyr	-0,30	1,03	1,50	-0,57	-0,74	0,61	0,25	4
Zakarpattia	x	x	x	x	x	x	x	x
Zaporizhzhia	x	x	x	x	x	x	x	x

Region	Factors						ID	Region's rank by ID
	F1	F2	F3	F4	F5	F6		
1	2	3	4	5	6	7	8	9
Ivano-Frankivsk	-0,48	0,42	-0,78	-0,94	-0,28	0,26	-0,30	12
Kyiv	0,51	-0,42	-0,62	1,30	-0,99	0,42	0,03	9
Kirovohrad	-0,16	0,18	-1,19	-0,62	0,69	-0,78	-0,31	13
Luhansk	x	x	x	x	x	x	x	x
Lviv	0,32	-0,77	0,52	0,55	-0,45	2,39	0,43	3
Mykolaiv	2,27	-0,86	1,63	-1,18	0,19	-1,42	0,10	7
Odesa	0,63	-1,97	-1,04	-0,69	-0,36	-0,32	-0,63	14
Poltava	0,53	1,04	-1,49	0,95	-0,63	-0,89	-0,08	11
Rivne	x	x	x	x	x	x	x	x
Sumy	-0,31	1,19	0,43	-0,91	-0,70	0,66	0,06	8
Ternopil	-0,64	0,52	0,25	0,56	1,21	-0,65	0,21	5
Kharkiv	0,59	0,12	-0,45	-0,75	2,20	1,73	0,57	2
Kherson	x	x	x	x	x	x	x	x
Khmelnytskyi	-1,23	0,33	0,75	0,31	1,63	-0,88	0,15	6
Cherkasy	x	x	x	x	x	x	x	x
Chernivtsi	-1,65	-1,32	-0,90	-0,72	-0,38	-0,10	-0,85	15
Chernihiv	-0,31	1,01	0,30	-0,70	-1,55	-0,59	-0,31	13

Source: authors' calculations

Figure 2 presents the distribution of the regions of Ukraine by the integral indicator of diversification (ID) in 2021 and 2023 for better visualization of the analysis.

By systematizing the results of the study, three groups of regions of Ukraine were identified according to the level of diversification, which are presented in Table 4.

Table 4. Distribution of the regions of Ukraine by the integral indicator of diversification over time

Level of regional diversification	2021	2023
The highest level of regional diversification (1st–5th place in the ID ranking)	Ternopil, Dnipropetrovsk, Vinnytsia*, Poltava, Kyiv	Dnipropetrovsk, Kharkiv, Lviv, Zhytomyr, Ternopil
Medium level of regional diversification (6th–10th place in the ID ranking)	Chernihiv, Cherkasy*, Zaporizhzhia*, Sumy, Kharkiv	Khmelnytskyi, Mykolaiv, Sumy, Kyiv, Volyn*
Low level of regional diversification (below 10th place in the ID ranking)	Khmelnytskyi, Donetsk*, Mykolaiv, Kirovohrad, Rivne*, Ivano-Frankivsk, Lviv, Odesa, Kherson*, Zhytomyr, Chernivtsi, Luhansk*	Poltava, Ivano-Frankivsk, Kirovohrad, Odesa, Chernihiv, Chernivtsi

Source: compiled by the authors
*Note. * — the region is absent from the 2023 ranking due to a lack of data*

Thus, in 2023, the highest level of diversification was observed in Dnipropetrovsk Region, while in 2021 it was in Ternopil Region.

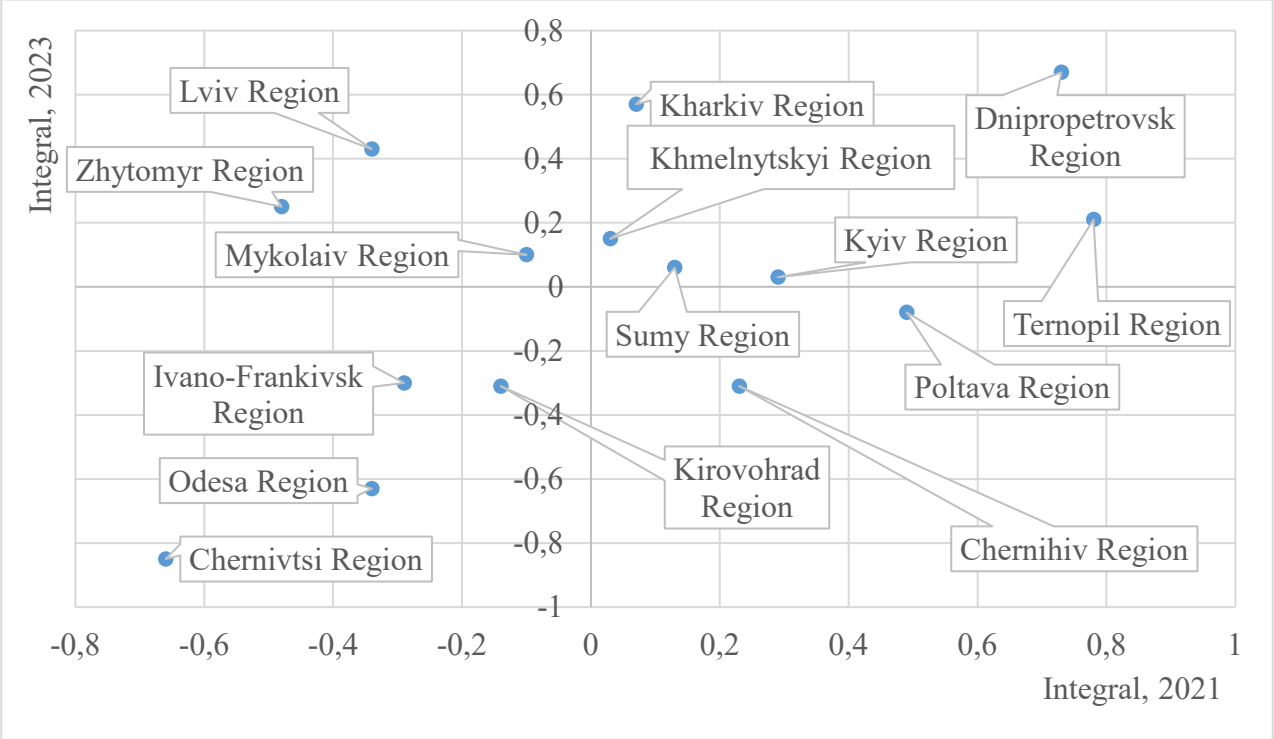

Figure 2. Distribution of the regions of Ukraine by the integral indicator of diversification in 2021 and 2023

Source: calculated and compiled by the authors

Conclusions

In 2023, compared to 2021, the level of diversification in most regions changed. In particular, it improved in the Kharkiv, Lviv, Dnipropetrovsk, and Zhytomyr regions, while it deteriorated in the Ternopil, Kyiv, and Poltava regions. These changes are partly associated with modifications in the structure of the factor space, as well as with the absence of data for certain regions, which led to their exclusion from the analysis.

However, overall, it can be argued that the ranking of regions by the level of diversification of spatial development has remained largely unchanged. This indicates insufficient attention paid to diversification issues in regional development strategies and plans. This, in turn, potentially creates risks to sustainable development not only during wartime and not only for frontline regions, but also in the period of post-war recovery.

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