Shevchenko, O., Varnalii, Z., Kharlamova, G., & Kuzmynchuk, N. (2023). Models for assessing crisis dynamics in disparities of Ukraine's regional economy to ensure the economic security of regions. *Journal of International Studies, 16*(1), 177-190. doi:10.14254/2071-8330.2023/16-1/12

Journal of International Studies

Centre of Sociological Research

Scientific Papers

Models for assessing crisis dynamics in disparities of Ukraine's regional economy to ensure the economic security of regions

Olga Shevchenko
Department of Regional Studies and Tourism, Kyiv National Economic University named after Vadym Hetman, Ukraine
kre_shevchenko.olga@knеu.edu.ua
ORCID 0000-0003-0386-7550

Zakharii Varnalii
Department of Finance, Taras Shevchenko National University of Kyiv, Ukraine
vzs1955@gmail.com
ORCID 0000-0002-6654-8760

Ganna Kharlamova
Department of International Relations, Political Science and Security Studies, Lucian Blaga University of Sibiu, Romania
Department of Economic Cybernetics, Taras Shevchenko National University of Kyiv, Ukraine
ganna.kharlamova@knu.ua
ORCID 0000-0003-3614-712X

Nataliia Kuzmynchuk
Department of Marketing, Management and Entrepreneurship V. N. Karazin Kharkiv National University, Ukraine
nkuzminchuk@ukr.net
ORCID 0000-0002-9844-3429

Abstract. The increase in the unevenness of indicators of regional socio-economic development in Ukraine is causing changes in regional economic security, in addition to the deterioration of national welfare. Therefore, there is a need to develop new theoretical and practical approaches for assessing such disparities and forecasting their dynamics. In this article, a toolkit for modelling crises and catastrophes in disparities of regional development is presented, using the

Received: April, 2022
1st Revision: February, 2023
Accepted: March, 2023

DOI: 10.14254/2071-8330.2023/16-1/12

example of Ukraine. The purpose of this study is to create models that assess the crisis dynamics in regional disparities in Ukraine, in order to develop tools for ensuring economic security in the region. To achieve this purpose, the following tasks have been identified: to evaluate convergent-divergent processes and the long-term interaction of regional disparity indicators; to simulate possible crises and catastrophes in various spheres of socio-economic development of regions according to the levels of their disparities; and to demonstrate the mutual dependence between disparities of the regions and levels of their economic security. The result of the crisis dynamic assessment is a set of predictive models of possible catastrophes that may occur in Ukraine's regions. This allows for obtaining reliable results for the qualitative analysis of stability factors of disparities in the socio-economic system, accounting for different time intervals that determine the peculiarities of the country's development. The array of constructed models is an effective tool for researching crisis processes in the dynamics of disparity indicators, as they allow for identifying and more thoroughly investigating non-linear cyclical processes in regional economic development, as well as predicting changes in levels of economic security. Such a toolkit allows for the development of a strategy for balanced regional and country development, and for ensuring regional economic security.

Keywords: regional economy, regional economic security, econometric modelling, catastrophes and bifurcations theory, dynamics of regional disparities, regulation of regional development.

JEL Classification: R12, R58, C51, C13, H12, O18

1. INTRODUCTION

Currently, the regional economy in Ukraine is facing a number of extreme external challenges. The destruction of production facilities, energy and transport infrastructure, and the outflow of human capital from the regions, which has increased several times in the conditions of a full-scale war, are causing further degradation of the regional economy and, at the same time, increasing disparities in regional socio-economic development. These threats to internal development are provoking a decrease in the level of regional economic security, which, together with other factors, leads to a deterioration of socio-economic regional development and the level of well-being.

Investigating the dynamics of regional disparities in order to ensure a sufficient level of economic security is a significant theoretical task. Its successful implementation will allow for the solution of a number of practical problems, including stimulating economic growth in regions, improving human capital (Luchko et al., 2019), and ensuring a high level of economic security.

The analysis of theoretical and methodological approaches to the research and analysis of dynamic processes in regions (Melnikova, 2015; Varnalii et al., 2018) has led us to conclude that the current methods and models for predicting crises in the spheres of the region's activities need further development. Therefore, developing a balanced economic model for regions and the country as a whole, and ensuring regional economic security is crucial.

The main goal of this article is to create models for assessing crisis dynamics in regional disparities in Ukraine's regions, in order to develop tools for ensuring regional economic security. To achieve this goal, the following tasks will be performed: analyzing convergent-divergent processes and long-term interaction

of regional disparity indicators; developing a model of crises and catastrophes in various spheres of regions according to the level of disparities; and demonstrating the mutual dependence between regional disparities and the levels of their economic security.

The methodological basis for the study of dynamic processes in disparities indicators during the period 2007-2021 and prediction of crisis situations by spheres of regional activity is the construction of models for assessing the crisis dynamics of regional development indicators, which will be further used to regulate the indicators of regional economic security.

Limitations of the study include the stochastic nature of separate indicators, the absence of some indicators (such as foreign direct investment), the crisis trends in Ukraine's economy in 2014-2016, which have affected the overall dynamics of disparity indicators, and the variability of the criteria for assigning regions to one or another level of economic security.

2. LITERATURE REVIEW

The study of dynamic processes in disparities indicators and the prediction of crises and catastrophes are based on numerous scientific works. For instance, Dore and Narayanan (2020) and Paun et al. (2021) comprehensively analyze the challenges of determining regional disparities and their consideration in public and local politics. Dmytryshyn and Bushynska (2017) discuss new tools for analyzing spatial differences between regions based on the knowledge economy. Amba and Gallo (2022) study the modelling of the dynamics of regional disparities.

Makarenko et al. (2020) present tools for assessing and forecasting the socio-economic development of Ukraine's regions. Varnalii et al. (2018), Iefimova et al. (2020), and Kozachenko et al. (2017) describe how to measure and predict the levels of economic security of the national economy and Ukraine's regions.

Storonianska et al. (2022) present the current situation in Ukraine's regions and propose several hypotheses: regions with higher economic activity concentration develop faster, technology-intensive regions with high innovation activity levels have higher chances of economic growth, economic growth can lead to growing interregional inequalities and imbalances in the long run, and economically powerful regions are more resilient to financial and economic crises.

Gur'yanova (2013) and Bril (2020) examine the evaluation of dynamics in regional development disparities. Melnikova (2015) analyzes structural shifts in the regional economy that lead to disparities. Manoilenko et al. (2020) consider modelling hierarchical systems, including the regional level, and Brumnik et al. (2014) and Klebanova et al. (2014) predict economic processes at the regional level.

Despite the numerous thorough articles devoted to the dynamics of disparities and the development of tools for their regulation, methods of quantitative research of the dynamic processes of disparities and the prediction of crisis situations in the region require further investigation.

3. METHODOLOGY

Previous research by Shevchenko et al. (2022) demonstrated the process component of studying the dynamics of regional development disparities indicators and predicting crisis situations. This component includes a description of tasks, research tools with an indication of applicable software packages, as well as presentation of the main results. A toolkit for studying dynamic processes in disparities indicators and predicting crisis situations by spheres of regional activity is designed to address a complex of tasks for managing regional development disparities, which include:

- constructing models for convergent-divergent processes of regional development disparities;

- creating models for long-term interaction of disparities indicators by spheres of regional activity;
- constructing models for assessing the crisis dynamics of regional development indicators, which is the object of the present study.

Seven spheres of regional development were examined: general economic, socio-demographic, structural, socio-economic, foreign economic, natural-ecological, and productive. In the work by Shevchenko (2021), evaluations of relationships between disparities indicators made it possible to designate three classes of regions: those with balanced disparities in a certain sphere, those with restrained (controlled) disparities of the sphere, and those with unrestrained (uncontrolled) disparities of the sphere.

At the same time, the majority of regions belong to the second class (with constrained disparities) in most areas of development. Classes of regions with greater territorial economic density show greater stress resistance in relation to various types of external influences. The results obtained in previous studies by Shevchenko (2021) showed a high level of disparities in regional socio-economic development. An increase in disparities is a significant catalyst for a consistently high rate of economic growth. In particular, observing such disparities prevents the implementation of a unified economic and social policy in the country and the formation of a national market for goods and services. It also hinders the use of advantages of territorial organization and specialization of regions, as well as the potential of interregional and cross-border cooperation.

Analysis of interregional disparities in Ukraine's regions shows a clear trend of their strengthening, as well as the growth of economic space fragmentation. An assessment of relationships between disparities indicators allows us to conclude that clusters with greater territorial economic density show greater stress resistance in relation to various types of "shocks". Therefore, an urgent socio-economic problem for the country and its regions is to increase measures of regional policy aimed at smoothing out interregional disparities in the spheres of regional life.

The regional development management system needs improvement of the disparity research methodology and dynamic processes of disparity indicators and prediction of crisis situations by spheres of the region's activities. At the same time, the spatial economy is considered not as a mono-object but as a complex multi-regional system that functions based on vertical and horizontal interactions (Gur'yanova, 2011), (Scenario models, 2013).

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Convergent-divergent processes and long-term interaction of regional disparities indicators

The building models for the analysis of convergent-divergent processes of uneven territorial development and long-term interactions of disparity indicators by regional spheres resulted in the grouping of indicators like this:

- socio-demographic disparities (ratio of migration movement – arrived/left, per 10,000 persons, sign X1),
- production disparities (ratio of the number of innovative products to the costs of innovation, X2),
- natural and ecological disparities (ratio between emissions of harmful substances and costs for environmental protection, X3),
- foreign economic disparities (coverage of imports by exports, X4),

- structural disparities (structure of gross value added (ratio of the amount of extractive and processing industry, X5)),
- socio-economic disparities (ratio between regional and national average incomes of the population (X6)),
- total economic disparities (ratio of savings to the gross regional product – GRP, X7).

The analysis of convergent-divergent processes showed that currently, there is an increase in divergent trends in the uneven development of Ukraine's regions. At the same time, interregional convergence is observed within groups of homogeneous clusters, the so-called "convergent clubs," where convergence occurs between these subgroups of regions. In the current period, the process of convergence of uneven socio-economic development of the regions has slowed down. Its activation requires the adoption of appropriate measures of public regulation, primarily related to raising the educational and professional level of the workforce, accelerating the development of the scientific and research sphere, stimulating innovative activity, and creating necessary production infrastructure. Taking into account the decisive role of the convergence of regions, it is necessary to use complex approaches to accelerate this process. These approaches should be implemented within the frames of innovative, scientific and technical, industrial, entrepreneurial, etc. types of public regulation policy.

In the construction of models of long-term interaction of disparities indicators in different spheres of regional activity, a decomposition of variances was carried out. In this way, the decomposition of variances makes it possible to estimate the proportions of these variances caused by shocks of differences and to estimate the degree of influence of links between disparity indicators accordingly. Variance decomposition analysis characterizes the relative importance of factors influencing the dynamics of change (variance) of a concrete system process. The analysis gave us the possibility to draw the following conclusions:

- the dynamics of changes in the savings to GRP ratio (X7) are practically explained by the dynamics in the previous periods (up to 60%), and almost 50% is caused by the influence of the ratio of innovative product amounts to the costs of innovation (X2), the influence of which becomes less significant over time.
- the dynamics of changes in the ratio of innovative products amount to the costs of innovation (X2) to a significant extent depending on the dynamics of the ratio of savings to GRP (X7) (from 40% to 65% in a quite short time, and the stable level of influence is maintained for a long time) and are due to fluctuations of the same indicator and its previous dynamics, which quickly changes from 60% to 35% in a quite short time and remains stable in the long term.

The analysis of mutual relations of disparities showed that the majority of regions belong to the class with restrained (controlled) disparities in most of the studied spheres. Therefore, the situation with disparities is regulated within the framework of improved public regional policy instruments. However, taking into account the external and internal challenges for regional development, further research should concern the prediction of crises and catastrophes in various spheres of regional activity.

4.2. Assessment of crisis dynamics of regional disparities

The study of crisis dynamics of disparities and prediction of catastrophes consists of constructing models for evaluating the crisis dynamics of regional development indicators. This is achieved by evaluating the nonlinear dynamics of indicator links using the theory of catastrophes and bifurcations. The model comprises three blocks:

- Identification of interconnections among disparities indicators.

- Evaluation and analysis of the nature and type of catastrophes of identified systems by spheres of activity, and analytical assessment of points of possible balance and bifurcations.
- Research on the nature and specifics of functions' extremes in indicators.

The decision to investigate catastrophe theory is justified by the need to understand and predict the instability of systems to which this theory is applicable. According to general approaches, a sudden change in the qualitative nature of a system's dynamics in conditions of smooth changes in its parameters is considered a catastrophe. In our case, a change in certain disparities indicators can lead to the destruction of the established contemporary status of economic relations in the country. This scenario should be predicted in advance to ensure a decrease in the economic securities levels of the regions.

The application of catastrophe theory tools allows for the evaluation of the current state of disparities indicators from the point of view of local or global stability and, most importantly, to determine points of balance and investigate the temporary deformation of functions. Considering excessive indicators of disparities as a threat to the stability of the economic system, we consider the loss of stability to be catastrophic. Even if this does not lead to the destruction of the entire economic system, it may lead to a transition to another path of its development. Accordingly, there may be a change in the parameters of economic security, which, in turn, causes the next change in regional unevenness. Therefore, it is expedient to study disparities with the help of catastrophe theory to predict disparities dynamics, sudden changes in disparities indices, and changes in the levels of economic security. To increase the reliability of calculations and forecasts, additional model devices should be used in the future.

The results can be used to determine the socio-economic catalysts of regional disparities. Moreover, the models are considered as a decision-making support tool regarding the prediction and prevention of crisis situations and the simulation of disparity regulation scenarios.

The construction of catastrophe models was carried out for the time interval 2007-2021 according to the algorithm presented in Figure 1.

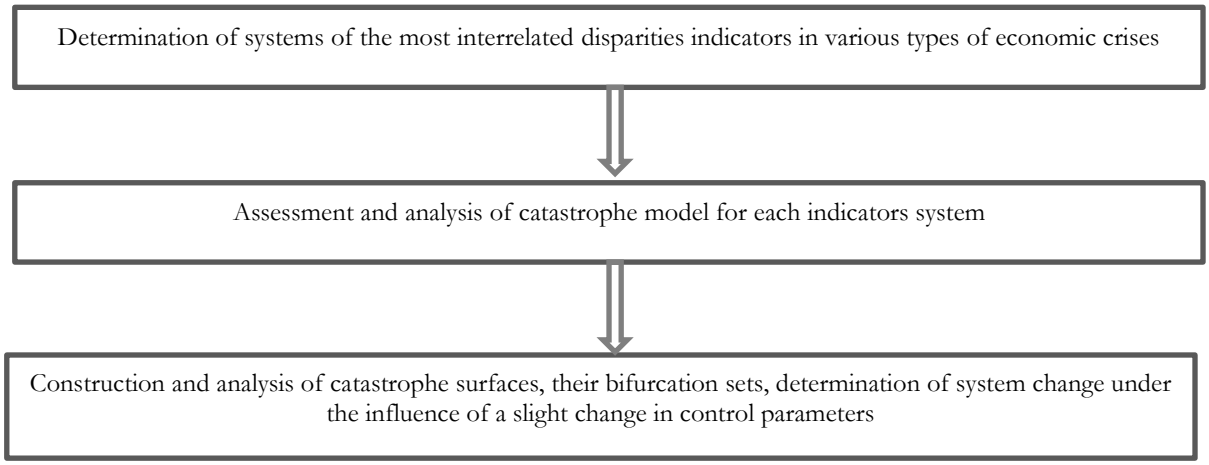

Figure 1. Algorithm for creating a catastrophe model of regional disparities

Source: authors' analysis based on the paper by Sergienko et al (2016).

Aggregated results of catastrophe models are presented below. Characteristics of cusp catastrophe models approximating the relationship between the growth rate of savings-to-Gross Regional Product (GRP) ratio (X7) – general economic disparities (in this model, it acts as a dependent variable Y) and the ratio of migration movement (X1) – demographic disparities for the period 2007-2021, are presented in Table 1.

Table 1

Characteristics of cusp catastrophe models approximating the relationship between the growth rate of savings to GRP ratio (X7)

Models of catastrophes	**Models equations**	**Determination coefficient**
Fold catastrophe model	$Y(X7) = X1^4$-4,429 $X1^2$+4,532 X1	0,558
Swallowtail catastrophe model	$Y(X7) = X1^5$-11,189 $X1^3$+19,91 $X1^2$-8,848 X1	0,888
Butterfly catastrophe model	$Y(X7) = X1^6$-14,512 $X1^4$+32,428 $X1^3$-25,451 $X1^2$+7,438 X1	0,889
Wigwam catastrophe model	$Y(X7) = X1^7$-279,53 $X1^5$+1329,36 $X1^4$-2398,23 $X1^3$+1929,8 $X1^2$-581,8 X1	0,903

Source: authors' estimates.

The summarized characteristics of model equations are presented in Table 2.

Table 2

Summarized characteristics of cusp model equations

1	Model is: Y(X7) = X1^4-a1*X1^2+a2*X1 (Spreadsheet10_(Recovered)) Dep. Var. : Y(*X7*) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	4,428477	0,182414	24,27702	0,000000	4,026985	4,829968
a2	4,531928	0,224009	20,23098	0,000000	4,038887	5,024970
2	Model is: Y(X7) = X1^5+a1*X1^3+a2*X1^2+a3*X1 (Spreadsheet10_(Recovered)) Dep. Var. : Y(*X7*) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	-11,1887	1,103381	-10,1404	0,000001	-13,6472	-8,73022
a2	19,9104	2,676278	7,4396	0,000022	13,9473	25,87356
a3	-8,8483	1,614014	-5,4821	0,000268	-12,4445	-5,25202
3	Model is: Y(X7) = X1^6+a1*X1^4+a2*X1^3+a3*X1^2+a4*X1 (Spreadsheet10_(Recovered)) Dep. Var. : Y(*X7*) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	-14,5115	14,03855	-1,03369	0,328259	-46,269	17,2459
a2	32,4275	50,95628	0,63638	0,540374	-82,844	147,6986
a3	-25,4506	61,43759	-0,41425	0,688388	-164,432	113,5308
a4	7,4380	24,60370	0,30231	0,769284	-48,219	63,0954
4	Model is: Y(X7) = X1^7+a1*X1^5+a2*X1^4+a3*X1^3+a4*X1^2+a5*X1 (Spreadsheet10_(Recovered)) Dep. Var. : Y(*X7*) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	-279,53	242,390	-1,15323	0,282105	-838,49	279,421
a2	1329,36	1184,218	1,12256	0,294181	-1401,45	4060,173
a3	-2398,23	2163,760	-1,10836	0,299912	-7387,87	2591,410
a4	1929,80	1752,267	1,10132	0,302788	-2110,94	5970,536
a5	-581,80	530,626	-1,09645	0,304789	-1805,43	641,824

Source: authors' estimates.

Table 2 presents the data that clearly indicates the statistical significance of all structural parameters in the models of "butterfly," "swallow tail," and "wigwam" types. However, the statistical significance of structural parameters is significantly lower in the "fold" type model. Such results suggest that the model includes elements with low accuracy or linear approximation, or incorrect connections of elements have been selected, or, as mentioned earlier, some limitations in the study, such as incomplete rows of data on foreign economic activity, may have distorted the result. Nonetheless, the economic nature of disparities, their sharp variability, and their connection with indicators/parameters of economic security demonstrate the usefulness of the catastrophe theory for evaluating a complex system of dynamic links between disparities indicators and the irreversibility of system trajectories. To improve the accuracy of the model, a dynamic series of indicators should be incorporated, and all indicators for all regions in the seven selected areas should be taken into account.

Figure 2 illustrates the surface of the most adequate "wigwam" catastrophe model. All subsequent figures are generated by the Maple program.

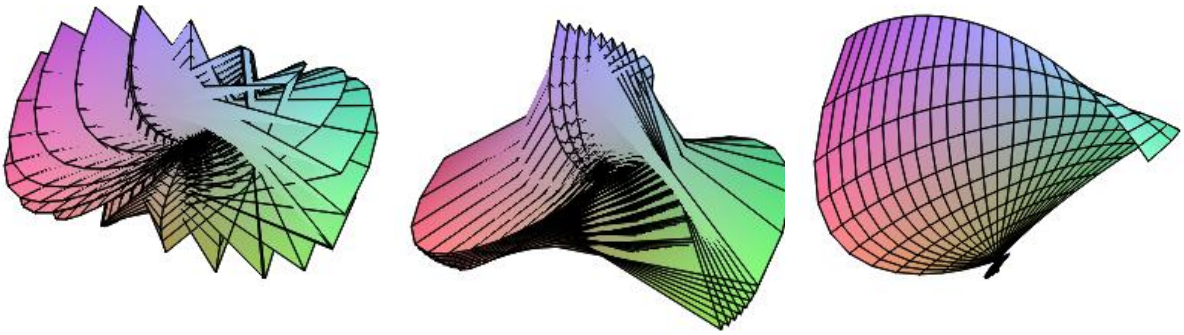

Figure 2. Wigwam-type catastrophe surface approximation for the relationship between the growth rate of savings to GRP ratio (*X7*)

Source: authors' estimates.

The system of equations describing the bifurcation set of catastrophe is the following (1):

$$> 7*X1^6-1397.65*X1^4+5317.44*X1^3-7194.69*X1^2+3859.6*X1-581.8 \quad (1)$$

$$> 42*X1^5-5590.6*X1^3+15952.32*X1^2-14389.38*X1+1163.6$$

Graphically, the bifurcation set in the projection of two- and three-dimensional space is presented in Figure 3.

When determining which indicators to apply cusp or umbilical catastrophe models to, dependent variables (Y) with the largest disparities were selected. Cusp catastrophes have two factors (dependent and independent), while umbilical catastrophes have three factors (dependent and two independent). A large number of models were then built, and the most adequate and economically interpretable models were chosen.

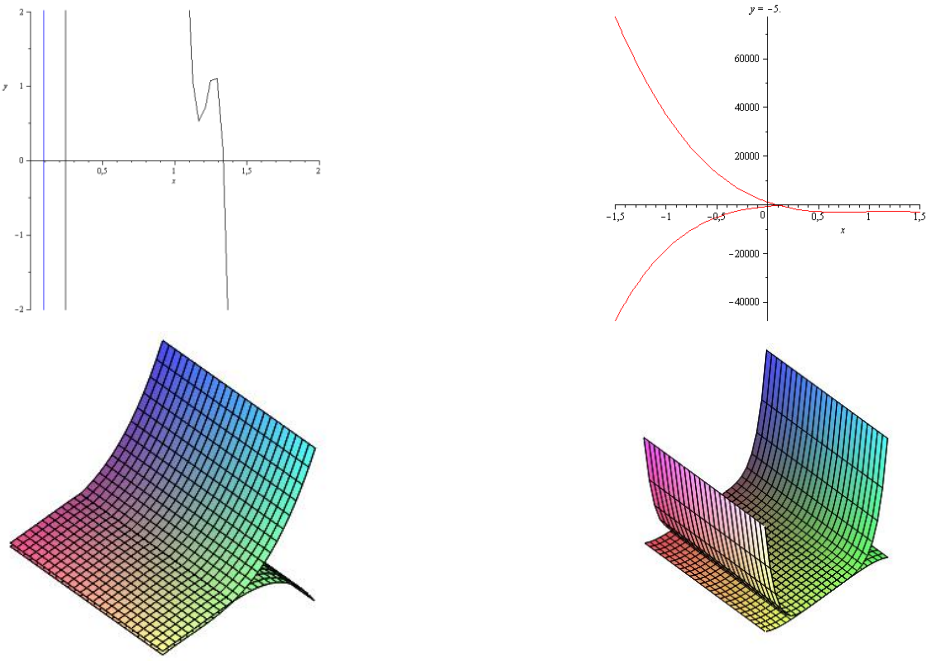

Figure 3. A bifurcation set of a "wigwam" cusp catastrophe

Source: authors' analysis.

This work demonstrates the most promising catastrophes obtained from simulation modelling. Table 3 presents the characteristics of umbilical catastrophe models that approximate the relationship between three factors:

- the growth rate of the coefficient of coverage by exports of imports in goods and services (X4) - a measure of foreign economic disparities,
- the savings to GRP ratio (X1) - a measure of general economic disparities,
- the growth rate of innovative products and costs of innovation ratio (X2) - a measure of production disparities.

In this model, the dependent variable Y represents the growth rate of innovative products and the costs of innovation ratio, and the analysis covers the period from 2007 to 2021.

Table 3

Characteristics of umbilical catastrophes models approximating the relationship between the growth rate of innovative products and costs of innovation ratio (X2)

Catastrophe models	**Model equations**	**Determination coefficient**
Hyperbolic umbilic	$Y(X2) = X4^3 + X7^3 - 4{,}959\ X4\ X7 + 2{,}32\ X4 + 1{,}682\ X7$	0,722
Elliptical umbilic	$Y(X2) = (X4^3)/3 - X4\ X7^2 + 0{,}859(X4^2 + X7^2) - 0{,}811\ X4 + 0{,}712\ X7$	0,836
Parabolic umbilic	$Y(X2) = X4^2\ X7 + X7^4 + 2{,}108\ X4^2 - 9{,}079\ X7^2 - 7{,}156\ X4 + 13{,}286\ X7$	0,395

Source: authors' analysis.

Summarized characteristics of model equations are presented in Table 4.

Table 4

Summarized characteristics of the equations of umbilical catastrophe models

1	Model is: Y(X2) = X4^3+X7^3+a1*X4*X7-a2*X4-a3*X7 (Spreadsheet10_(Recovered)) Dep. Var. : Y(X2) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	-4,95894	0,169560	-29,2459	0,000000	-5,33674	-4,58114
a2	-2,32021	0,268353	-8,6461	0,000006	-2,91814	-1,72228
a3	-1,68198	0,401920	-4,1849	0,001873	-2,57752	-0,78645
2	Model is: Y(X2) = (X4^3)/3-X4*X7^2+a1*(X4^2+X7^2)-a2*X4-a3*X7 (Spreadsheet10_(Recovered)) Dep. Var. : Y(X2) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	0,858947	0,064695	13,27686	0,000000	0,71480	1,003096
a2	0,810585	0,205331	3,94769	0,002741	0,35308	1,268092
a3	-0,711448	0,306674	-2,31989	0,042781	-1,39476	-0,028136
3	Model is: Y(X2) = X4^2*X7+X7^4+a1*X4^2+a2*X7^2-a3*X4-a4*X7 (Spreadsheet10_(Recovered)) Dep. Var. : Y(X2) Level of confidence: 95.0% (alpha=0.050)					
	Estimate	Standard error	t-value df = 11	p-value	Lo. Conf Limit	Up. Conf Limit
a1	2,1082	1,968067	1,07121	0,311960	-2,3439	6,56029
a2	-9,0795	1,866962	-4,86326	0,000892	-13,3029	-4,85617
a3	7,1561	4,515650	1,58474	0,147486	-3,0590	17,37125
a4	-13,2856	4,442836	-2,99034	0,015192	-23,3360	-3,23520

Source: authors' analysis.

Based on the information presented in Tables 3 and 4, it is evident that the "elliptical umbilicus" model exhibits statistically significant structural parameters and a higher coefficient of determination compared to both the "hyperbolic umbilicus" and "parabolic umbilicus" models. Nevertheless, similar to the previously discussed analysis of single variable functions (as shown in Table 2), we must note that the significant economic disparities, their rapid fluctuations, and their correlation with indicators and parameters of economic security, present opportunities for the application of the aforementioned catastrophe theory.

The results obtained lead us to depict the surface of the most appropriate catastrophe model of the "elliptical umbilical" type in Figure 4

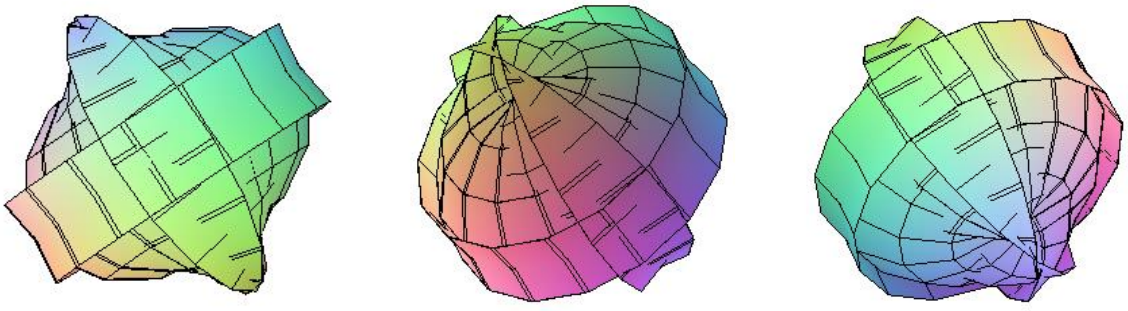

Figure 4. The surface of an "elliptical umbilic" catastrophe, approximating the relationship between the growth rate of innovative products and the costs of innovation ratio (X2)

Source: authors' analysis.

Graphically, Figure 5 presents the bifurcation set in both two- and three-dimensional projections.

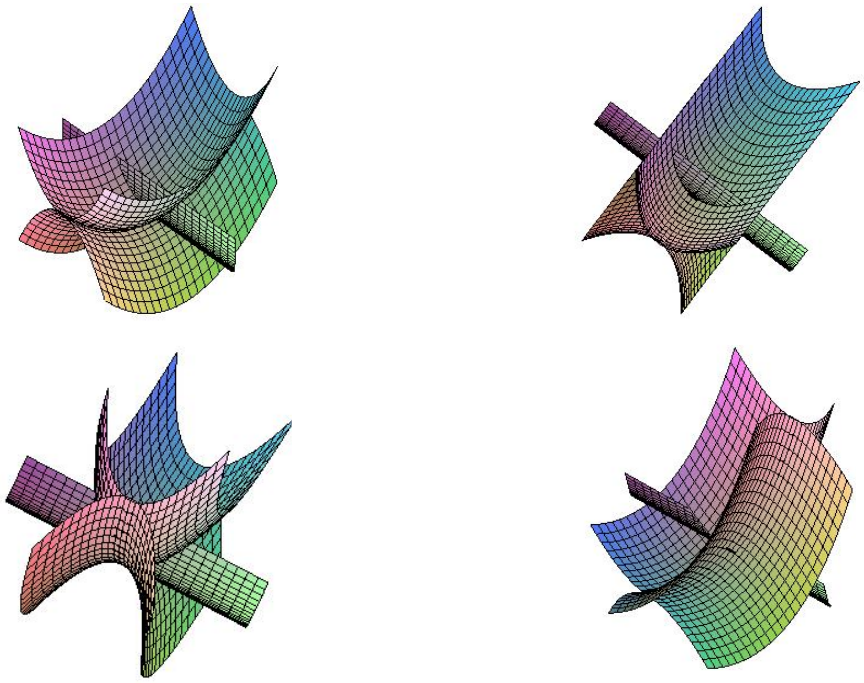

Figure 5. Bifurcation set of elliptical umbilic catastrophe

Source: authors' analysis.

The outcome of this study is a model that evaluates the crisis dynamics of regional development indicators through a series of predictive models of potential catastrophes that could occur in various regions. This enables researchers to acquire dependable outcomes for qualitative analysis of stabilization factors for economic disparities, considering different time intervals that define the characteristics of a country's development overall. The constructed models serve as a useful tool for researching crisis processes in the dynamics of regional economies as a whole, as well as in individual indicators of disparities, by detecting and investigating non-linear cyclical processes.

The results obtained suggest that cyclical crises affect primarily regions with balanced development disparities, which are heavily reliant on global markets. Additionally, cyclical crises have a significant impact on regions with uncontrolled disparities in certain sectors. However, for regions with controlled disparities, a comparative analysis of theoretical and empirical values of model errors revealed the presence of a high level of potential. Nonetheless, most of the critical points for the studied indicators fall within the bifurcation set, which supports the hypothesis that trajectories of indicators become unpredictable after reaching the bifurcation point, with certain development scenarios. This is characteristic of cyclical processes, particularly during crises.

The study also shows the significant sensitivity of economic disparity indicators to external "shocks" and the presence of spatial clustering of reactions to such shocks, as demonstrated by the high volatility of regional development indicators during periods of cyclical decline and growth. Anomalous dispersion is another indicator that suggests the formation of a crisis in regions. The obtained results indicate that anomalous dispersion is a characteristic of general economic disparities, socio-demographic disparities, foreign economic disparities, and production disparities, which suggests the possible formation of crises not only in the regions but also on the scale of regional cluster groups and the entire country.

4.3. Dependence of crisis dynamics of regional disparities on regional economic security

Identified aggregates of predictive models of possible catastrophes that may occur in regions are directly related to the ability to ensure the level of regional economic security. The level of regional unevenness and crisis regional situations determines the weakness of one or another component of the country's economic system as a whole. In turn, the level of regional economic security directly affects the level of its socio-economic development and the formation of disparities.

The development of an economic security system involves measures to observe, preserve, and strengthen the economic security of the regions. The first step is to assess the levels of economic security in Ukraine's regions and classify the regions according to these levels. The second is the assessment of threats to economic security. The third is to reduce threats to regions with a low level of security and maintain a stable level of economic security and strengthen it for regions with medium and high levels of security. The fourth step is the development of systemic measures for groups of regions in accordance with their security levels and the transfer of these measures to public regional policy.

To assess the defined levels of economic security in the regions of Ukraine, it is expedient to determine indicators by which statistical analysis is carried out. While discussing the economic security of the region and the community, it is worth highlighting those indicators that will most clearly reflect the situation at production, finance, innovation, service, human, etc. capital. In addition, it is expedient to focus attention on the indicators for which statistical observations are conducted in the country. Therefore, it is proposed to include the following in the list of indicators:

- tax provision of the region (characterizes the sufficiency of the region's taxes and other fees);
- population migration within the country (shows the intensity of population movements between regions);
- external migration (shows the movement of the population outside the country);
- import dependence (shows the degree of dependence of the region's domestic market on imported production);
- interregional exchange of goods and services (shows the extent to which regions are embedded in the domestic market and what the degree of their economic orientation on the foreign market is);
- capital investment in the region (shows the provision of funds to the region);
- innovative development of the region (shows the degree of innovation in the region);
- the level of unemployment (shows the need for employment);
- the amount of debts in wages (shows the change in welfare).

The list of indicators is not complete and can be supplemented according to the situation and the needs of economic analysis. In particular, the list can include indicators of the social sphere – social protection and social security (Jurgilewicz et al 2019, 2020), the amount of provision of educational services, and the amount of medical care. Also, the indicators required for the analysis may differ depending on the group of regions according to the level of economic security (high, medium, or low).

Grouping regions by levels of economic security, assessment of economic security threats in different regions, and the development of appropriate measures to adjust security levels result in a systemic policy aimed at stabilizing economic security in Ukraine's regions in general, which becomes a component of public regional policy. Regional policy is regulated in medium-term regional development strategies. It is expedient to include complex measures for maintaining and strengthening the security of the regional economy in measures of regional strategies, ensuring coordination of measures in groups of regions with different levels of economic security and functional types of territories (territories of recovery, regional poles of growth, territories with special conditions for development, and territories with sustainable development). In this

way, it is possible to ensure compliance with the goals for regional development and the need to ensure the economic security of the regions

5. CONCLUSION

The research indicates that the task of eliminating disparities in regional development in Ukraine has not been accomplished in the past fifteen years. This highlights the inefficiency of regional policy and insufficient measures to equalize the indicators of regional socio-economic development. To address this, it is necessary to implement modern tools for researching the dynamics of disparity indicators based on the theory of catastrophes and bifurcation. This will allow for the determination of a stabilization strategy and promote further qualitative development of the regional economy, which is determined by tight non-linear asynchronous links of main disparity indicators in regional socio-economic development.

To reduce the level of regional development disparities in specific spheres, a scientifically balanced public policy of structural transformations of the regional economy and forecasting crisis situations must be implemented. This policy should be based on the principles of a comprehensive, proportional approach in the process of regional strategic planning. The connection between the characteristics of regional disparities and the levels of economic security of the territories makes it necessary to consider potential crises and catastrophes of the regional economy resulting from unevenness as a basis for adjusting the levels of regional economic security.

To level the indicators of disparities and prevent deterioration of the levels of regional economic security, it is essential to develop a regional policy program that considers the geographical, social, and economic features of the regions, principles of financial decentralization, and new reforms for local self-government. The program-target policy should provide motivational mechanisms for regions with significant problems, the possibility of obtaining public and international grants for implementing perspective regional programs, and a reduction of disparity indicators. These specified measures should contribute to achieving an appropriate level of regional economic security.

ACKNOWLEDGEMENT

This work was supported by Hasso Plattner Foundation through the grant LBUS-UA-RO-2023, financed by the Knowledge Transfer Center of the Lucian Blaga University of Sibiu.

REFERENCES

Amba, M.C.O., & Le Gallo, J. (2022). Specification and estimation of a periodic spatial panel autoregressive model. *J Spat Econometrics*, 3(13). https://doi.org/10.1007/s43071-022-00028-5.

Bril', M. S. (2020). Methodology of formation of a balanced system of indicators of regional differentiation. *Biznes Inform*, 4, 133–142. https://doi.org/10.32983/2222-4459-2020-4-133-142.

Brumnik, T., Klebanova, L., Gur'yanova, L., Sergienko, O., Kavun, S., & Nepomnyaschiy, V. (2014). Synthesis of systems modeling for early crisis forecasting and prevention. *European Journal of Scientific Research*, 118 (1), Jan, 7–22.

Dmytryshyn, L., & Bushynska, V. (2017). Spatial differentiation of the regions of Ukraine concerning the knowledge economy. *Baltic Journal of Economic Studies*, *3*(1), 31-35. https://doi.org/10.30525/2256-0742/2017-3-1-31-35.

Dore, P., & Narayanan, K. (2020). Inter-temporal differences in regional development. *Area Development and Policy*, 5(4), 376-389. https://doi.org/10.1080/23792949.2020.1741413

Gur'yanova, L. (2011). Models of interregional convergence analysis. *Visnyk Skhidnoukrayins'koho Natsional'noho Universytetu im. V. Dalya,* 2 (156-1), 59–65.

Gur'yanova, L. (2013). Modeling of balanced socio-economic development of regions. Berdyans'k: FOP Tkachuk O. V.

Iefimova, G., Labartkava, A., & Pashchenko, O. (2020). Methodical support of assessment of the development of economic security of the region. *Baltic Journal of Economic Studies*, *6*(5), 113-117. https://doi.org/10.30525/2256-0742/2020-6-5-113-117.

Jurgilewicz, M., Kmiotek, K., Dankiewicz, R., & Misiuk, A. (2019). Mediation in civil matters as an example of the method used in legal security management and optimization of costs of proceedings. *Journal of Security and Sustainability Issues*, 9(2), 595-602.

Jurgilewicz, M., Lorek, M., Ovsepyan, A., & Kubiak, M. J. (2020). The police's role in the field of improving functioning fuel sector as an element of energy safety management in Poland. *WSEAS Transactions on Business and Economics,* 17, 657 - 664

Klebanova, T. S., Gur'yanova, L. S., & Shevchenko I. K. (2014). Model basis of the early warning and localization of crises in economic systems of territories. *Actual problems of economics*, 3 (153), 201–211.

Koliada, U. Adaptive paradigm of economic dynamics modeling (2011). Kyiv: KNEU.

Kozachenko, A., & Bukolova, V. (2017). Socioeconomic security of a region as an object in economic security studies at the mesolevel. *Baltic Journal of Economic Studies*, *3*(5), 188-195. https://doi.org/10.30525/2256-0742/2017-3-5-188-195.

Luchko, M., Arzamasova, O., & Vovk, I. (2019). Personnel potential of national economy and gross domestic product: The case of Ukraine. *Montenegrin Journal of Economics*, *15*(2), 59-70. https://doi.org/10.14254/1800-5845/2019.15-2.5.

Makarenko, S., Oliinyk, N., & Kazakova, T. (2020). Features of assessment and forecasting of socio-economic development of regions in Ukraine. *Baltic Journal of Economic Studies*, *6*(5), 129-136. https://doi.org/10.30525/2256-0742/2020-6-5-129-136.

Manoilenko, O. V., Sergienko, O. A., & Gaponenko, O. Ye. (2020). Modeling of innovative activity of hierarchical systems: assessment of diffusion and economic effect of the existing potential and results. *Problemy ekonomiky,* 1 (43), 312–324. https://doi.org/10.32983/2222-0712-2020-1-312-324.

Melnikova, M. V. (2015). Matrix models in planning structural changes in the economy of the old industrial region. *Aktual'ni problemy rozvytku zovnishn'oekonomichnoyi ta innovatsiynoyi diyal'nosti:* coll. of science works of DonSUU. "Economy"; vol. XVI, issue 295. Mariupol: DonDUU.

Paun, C., Musetescu, R., Isaic, R., Manea, G. C., & Shayb, H. (2021). Economic resilience and the state: A global panel analysis. *Economics, Management and Sustainability*, *6*(2), 34–45. https://doi.org/10.14254/jems.2021.6-2.3

Scenario models of balanced socio-economic regional development. (2013). Eds. T. S. Klebanova, & O. V. Mosenkov. Berdyans′k: FOP Tkachuk O. V.

Sergienko, O., Tatar, M., & Golofaieva, I. (2016). The catastrophe theory as a conceptual and methodological basis for assessing the stability of socio-economic systems. *Problemy ekonomiky*, 2, 184 - 193.

Sergienko, O., Guryanova, L., & Nevezhyn P. (2014). Modelling of Socioeconomic Crises in Early Warning Systems. *Actualni problemy economiky,* 8 (158), 471 – 479.

Shevchenko, O. (2021). Elaboration of a mechanism for regulating disparities of regional socio-economic development by fuzzy logic methods. *Science and Innovation*, *17*(1), 18–28. https://doi.org/10.15407/scine17.01.018

Shevchenko, O. (2021). The toolbox for recognizing the groups of Ukraine's regions by indicators of disparities in their social and economic development. *Biznes Inform*, 7, 115–126. https://doi.org/10.32983/2222-4459-2021-7-115-126.

Shevchenko, O., Shevchuk, O., & Polovynko, B. (2022). Regulation of dynamic processes in the indicators of disproportions of Ukrainian regions: operational and logistic approach. *Baltic Journal of Economic Studies*, *8*(5), 198-208. https://doi.org/10.30525/2256-0742/2022-8-5-198-208.

Storonianska, I., Nowakovska, A., Benovska, L, & Dub, A. (2022). Imbalances and risks of the regional development of Ukraine's economy under conditions of instability. *Agricultural and Resource Economics,* 8(3), 81-97. https://doi.org/10.51599/are.2022.08.03.05.

Varnaliy Z., Onyshchenko S., & Zavora T. (2018). Construction complex development influence on region social and economic security. *International Journal of Engineering & Technology, 7*(3), 469-472**.** https://doi.org/10.14419/ijet.v7i3.2.14574.