REGIONAL ECONOMIC SECURITY: ANALYSIS BY REGIONS AND DEVELOPMENT OF A RISK INDEX

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Abstract: The article improves scientific and methodological approaches to assessing economic security and proposes a new integrated mechanism designed to overcome the limitations of existing composite methods. The proposed index is based on a system of indicators that covers macro-stability, labor market conditions, socio-economic balance, and interregional spatial effects. The findings confirm that the author-developed index is practically useful for an in-depth analysis of regional disparities, identifying spatial effects within economic security, and formulating targeted regional development policies.

Keywords: regional economic security; spatial economic spillovers; robust normalization; economic risk; composite index; entropy method; AHP; W-matrix; interregional disparities; risk index; regional development; economic stability.

Introduction

In recent years, Uzbekistan has been implementing consistent reforms aimed at modernizing the economy, increasing regional competitiveness, and strengthening the principles of sustainable development. Nevertheless, significant disparities remain among regions in terms of economic growth rates, investment activity, household incomes, employment indicators, infrastructure quality, and the business environment. These disparities contribute to the weakening of economic security in certain regions, intensify systemic risk factors, and lead to uneven economic stability. Therefore, assessing regional economic security, identifying potential threats in advance, and scientifically evaluating risk levels are regarded as pressing scientific and practical tasks of the present time.

Regional economic security essentially reflects a region’s economic stability, production capacity, financial independence, population welfare, and the resilience of its economic system to internal and external shocks. The acceleration of digital economy processes necessitates the development of new methodological approaches for identifying, monitoring, and evaluating these conditions. In particular, the digital economic security index enables comprehensive analysis of the real economic situation across regions, including levels of economic activity, investment attractiveness, budget stability, business environment transparency, innovation activity, energy supply reliability, infrastructure conditions, and socio-economic risks.

The relevance of this study is explained by the growing need to assess economic security using digital indicators amid deepening regional economic disparities. While traditional statistical methods

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highlight only individual aspects of the situation, the risk-index methodology provides a systematic and measurable evaluation of complex regional economic conditions. A risk index based on the digital economic security index forms the necessary information base for quantitatively assessing regional economic imbalances, classifying regions according to risk levels, identifying priority areas, and allocating resources in a targeted manner.

Accordingly, the purpose of this article is to conduct an in-depth study of the economic security status of Uzbekistan's regions, identify disparities based on the digital economic security index, and develop a new methodological approach for classifying regions according to risk levels. The research findings provide a foundation for developing scientific and practical conclusions aimed at improving regional economic policy, reducing economic disparities, and strengthening regional stability.

Review of literature on the subject

Numerous foreign and domestic researchers have conducted extensive studies on regional disparities, risk factors, and production capacity, significantly contributing to the development of the economic security concept. These studies demonstrate that regional economic imbalances, differential allocation of investment flows, disparities in infrastructure development, and differences in gross regional product are key determinants of economic security.

Crescenzi and Rodriguez-Pose (2012), in their study of European Union regions, analyze in depth the impact of infrastructure provision, agglomeration processes, and innovation capacity on economic growth. While emphasizing that transport and communication infrastructure are necessary conditions for growth, the authors highlight that growth is more strongly associated with human capital, knowledge spillovers, and institutional quality [1]. Lessmann (2013) empirically examines the impact of foreign direct investment (FDI) on regional inequality in developing countries and finds that the concentration of FDI in economically developed centers intensifies regional disparities. The study indicates that countries with more flexible economic systems tend to achieve a more balanced territorial distribution of investment [2]. Fredriksen (2012) investigates income inequality dynamics in the European Union and concludes that although income inequality increased in many countries due to rapid growth among high-income groups, overall income disparities within the Union declined as a result of accelerated growth in new member states. The study underscores that income inequality has strategic implications not only for economic performance but also for social stability [3].

Additional research on GDP disparities across European regions reveals that the highest-performing region may exceed the lowest by up to ten times. Such disparities may reduce investment attractiveness in lagging regions, stimulate labor migration, and increase socio-economic instability risks [4]. Hacker (2021), in an edited volume, substantiates that differences in regional development rates across EU countries are determined by production capacity, infrastructure quality, competitiveness, and social capital. The contributors emphasize that differentiated regional policies directly influence the formation of regional security [5]. Dynnikova et al. (2021) examine economic security indicators in the context of fiscal federalism in the Russian Federation. Their findings suggest that although federal transfers may support short-term stability, they can weaken long-term regional economic independence [6]. Zubarevich and Safronov (2024), in their comprehensive study of post-Soviet states, demonstrate that regional disparities largely stem from economic models centered around resource-rich territories. They note that in Uzbekistan, Kazakhstan, and Russia, oil, gas, or industrial-resource-rich regions generate the majority of gross regional product, while other regions remain economically weaker [7]. Kriventsova (2021), analyzing theoretical interpretations of economic security, argues that regional security indicators remain insufficiently standardized from a scientific perspective, highlighting the need for an integrated approach that combines macro-, meso-, and micro-level factors [8]. Jemulin et al. (2023) identify investment security as a core component of regional economic security, emphasizing that uneven post-pandemic recovery of investment

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potential has generated new risks [9]. Shakhova and Speranskiy (2021) analyze the stability of the regional investment climate during the pandemic and find that reductions in investment flows had more severe negative impacts on economic security in regions with weaker infrastructure [10].

Research conducted by Uzbek scholars has also produced significant scientific findings in this field. E.N. Raximov (2023) identifies a system of indicators for the concept of regional economic security and emphasizes the necessity of using integral indices in its assessment. According to his view, disparities in gross regional product, infrastructure provision, and investment potential among regions constitute an integral part of economic stability [11]. D. Baxtiyorova (2025) analyzes the interrelationship between regional infrastructure development and stability, highlighting that infrastructure deficiencies represent one of the most sensitive components of economic security. The study concludes that infrastructure gaps may become a determining factor of long-term regional competitiveness [12].

The reviewed literature indicates that comprehensive methodologies for assessing regional economic security—particularly those that form risk indices based on digital indicators and integrate temporal and spatial factors—remain limited in scope. In particular, the interregional dynamics of economic security, the root causes of economic imbalances, and quantitative approaches to measuring regional disparities have been insufficiently explored in academic research. Therefore, developing scientifically grounded risk indices for assessing economic security at the regional level, empirically testing them using panel data, and advancing approaches aimed at identifying the causes of regional imbalances remain urgent scientific and practical tasks.

Research Methodology

In this study, several scientific research methods were employed to assess the state and dynamics of regional economic security. First, a systemic approach was applied to identify internal interconnections among economic indicators. Methodologies enabling the analysis of regional disparities were comparatively examined, and empirical studies evaluating their effectiveness were systematically analyzed. An expert evaluation method was used to construct the system of indicators, while mathematical and statistical methods were applied for data normalization.

Analysis and Results

Although methodological approaches developed for assessing regional economic security rely on different frameworks, they all share the objective of identifying interregional economic imbalances, quantitatively evaluating risk factors, and comparing levels of sustainable development. Under rapidly changing economic conditions, intensified interregional competition, and the influence of external economic shocks, it is essential to conduct an in-depth analysis of the scientific validity and practical relevance of various assessment tools. Accordingly, before selecting the approaches applied in this study, it was deemed appropriate to thoroughly examine the principal methods widely used in international and domestic scientific practice.

In particular, composite index systems, entropy-based weighting methods, the TOPSIS model as a multi-criteria evaluation approach, the Analytic Hierarchy Process (AHP) based on expert judgments, threshold value models, and clustering algorithms demonstrate varying analytical capabilities in determining regional economic security. Comparing the potential, mathematical foundations, and application mechanisms of each method is methodologically important for identifying which tool produces more accurate results in assessing regional economic stability, investment attractiveness, and socio-economic risks. The table presented below systematizes these methodologies by summarizing their conceptual content, algebraic structure, and practical scope of application. The structure of the table serves to scientifically compare existing approaches to assessing regional economic security and to substantiate the selection of methods applied in subsequent stages of the research (Table 1).

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Table 1. Analysis of Existing Methodologies for Assessing Economic Security in Regions[1]

Methodology	Characteristics of the Methodology	Algebraic Expression of the Methodology	Algebraic Description of the Methodology	Author and Source
Composite Index of Regional Security (CI)	The composite index specializes in aggregating numerous economic and social indicators into a single unified measure. Each indicator is weighted and normalized. This method is widely used to analyze the overall economic security status of regions. It simplifies complex systems and creates an index convenient for comparison.	$CI_i = \sum_{j-1}^{n} w_j \cdot \left(\frac{x_{ij} - x_j^{min}}{x_j^{max} - x_j^{min}}\right)$	**CI_i** – overall index value for region *i*; **w_j** – weight of indicator *j*; **x_{ij}** – value of indicator *j* in region *i*; **x_j^{max}** – **x_j^{min}** – minimum and maximum values of indicator *j* across all regions.	UNDP (2022), Mukhina (2021)
Entropy Weight Method	The entropy method measures the dispersion of data within indicators and is used as an objective criterion for determining weights. The higher the entropy level, the greater the informational value contained in the indicator. This methodology is particularly applied in evaluation systems sensitive to statistical variations.	$W_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)}$; $e_j = -k\sum_{i-1}^{m} p_{ij} \ln\left(p_{ij}\right)$; $p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$	**W_j** – weight of the indicator; **e_j** – entropy (degree of data dispersion); **p_{ij}** – relative value of indicator *j* in region *i*; **$k = 1/\ln(m)$** – normalization coefficient; **m** – number of regions.	Zhou et al. (2020)
TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)	TOPSIS evaluates alternatives based on their distance from the ideal (best) and anti-ideal (worst) solutions. The level of economic security is determined according to proximity to the ideal option. It is particularly effective in decision-making, resource allocation, and setting investment priorities.	$C_i = \frac{S_i^-}{S_i^- + S_i^+}$; $S_i^{\pm} = \sqrt{\sum_{j=1}^{n} w_j(x_{ij} - x_j^{\pm})^2}$	**C_i** – closeness index of region *i* to the ideal solution; **$S_i\pm$** – distance of region *i* to the ideal solution; **S_i^-** – distance of region *i* to the anti-ideal solution; **w_j** – weight of indicator *j*; **x_{ij}** – indicator value; **$x_j\pm$, x_j^-** – ideal and anti-ideal values.	Hwang & Yoon (1981)
AHP (Analytic Hierarchy Process)	AHP is an expert-based approach that structures indicators hierarchically for decision-making. Designed for complex systems, it includes mechanisms for checking the consistency of indicator comparisons (CI, CR).	$Aw = \lambda_{max} w$; $CI = \frac{\lambda_{max} - n}{n-1}$; $CR = \frac{CI}{RI}$	**A** – pairwise comparison matrix of indicators; **w** – weight vector; **λ_{max}** – principal eigenvalue; **CI** – consistency index; **CR** – consistency ratio; **RI** – random index.	Saaty (1980)
Threshold Model	The threshold model determines the presence of risks by defining safe and critical values for each indicator. It is useful for rapid monitoring and risk signaling. This method assesses the overall risk condition by counting identified threat indicators.	$R_{ij} = \begin{pmatrix} 1, & x_{ij} > T_j \\ 0 & x_{ij} \leq T_j \end{pmatrix}$; $R_{ij} = \sum_{j=1}^{n} R_{ij}$	**R_{ij}** – equals 1 if the indicator is in a risk state and 0 if safe; **T_j** – threshold risk value of indicator *j*; **x_{ij}** – regional value; **R_i** – total risk score (sum of risk indicators).	Ivanova (2018)
Clustering (K-means)	This method groups regions into clusters based on similar economic characteristics. Through clustering, regions are typologized, enabling the development of strategic management decisions. It is an important tool for identifying regional imbalances.	$d_{ik} = \sqrt{\sum_{j=1}^{n}(x_{ij} - \mu_{kj})^2}$	**d_{ik}** – distance between region *i* and cluster center *k*; **x_{ij}** – value of indicator *j* in region *i*; **μ_{kj}** – mean value of indicator *j* in cluster *k*.	Yashin & Puzov (2006)
Z-index (Taxonomy Method)	The Z-index performs statistical normalization of indicators and measures each region's deviation from the ideal state. This objective, statistically grounded method provides reliable results in assessing economic security and quantitatively analyzes the level of imbalances.	$z_{ij} = \frac{x_{ij} - \bar{x}_j}{\sigma_j}$; $D_i = \sqrt{\sum_{j=1}^{n}(z_{ij} - z_j^0)^2}$	**z_{ij}** – Z-standardized value of the indicator; **$\bar{x}_j$** – mean value of the indicator; **σ_j** – standard deviation; **z_j^0** – ideal value; **D_i** – deviation of region *i* from the ideal state.	Taxonomy School (EU, 2015)

The methodologies presented in the table demonstrate varying analytical capabilities in assessing regional economic security. Among them, composite indices, entropy weighting, TOPSIS, and clustering approaches stand out as the most widely applied tools in practice. Composite indices enable an integral assessment of multi-indicator systems and provide a simplified basis for

[1] **Source:** Developed by the author based on an analysis of existing scientific research.

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interregional comparison. However, the subjective determination of weights may limit their robustness. In contrast, the entropy method allows for the calculation of objective weights based on data dispersion, although its reliance solely on quantitative indicators may prevent it from fully capturing certain economic conditions. The TOPSIS approach evaluates economic security based on proximity to an ideal solution and is effective in prioritizing management decisions; nevertheless, its sensitivity to the normalization process requires careful application.

The K-means clustering method is highly effective for identifying regional typologies and grouping regions based on similar economic characteristics. However, the subjective selection of the number of clusters and its sensitivity to minor data variations may restrict its applicability. The Z-index (taxonomy method), grounded in objective statistical principles, provides high accuracy in measuring regions' deviations from an ideal state, although excessive sensitivity to mean values may reduce result stability. The AHP model is suitable for hierarchical evaluation of complex systems, yet its strong dependence on expert judgment may slightly reduce objectivity. The threshold model enables rapid identification of risk conditions but cannot substitute for comprehensive assessment.

In this regard, the methods outlined in the table highlight different dimensions of regional economic security. Some are more suitable for comprehensive integral evaluation, while others are effective for risk identification or regional typology analysis. However, practical research indicates that none of these methods alone fully captures economic security; the most reliable results are achieved through an integrated application of multiple approaches. Below, the capabilities of these methodologies are evaluated according to various parameters (Table 2).

Table 2. Evaluation of Regional Economic Security Methodologies by Parameters[2]

Parameters	Composite Index of Regional Security (CI)	Entropy Weight Method	TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)	AHP (Analytic Hierarchy Process)	Threshold Model	Clustering (K-means)	Z-index (Taxonomy)
P1 – Multi-indicator assessment capability	*	*	*	*	N/A	N/A	*
P2 – Objective weight calculation capability	N/A	*	N/A	N/A	N/A	N/A	N/A
P3 – Risk identification capability	N/A	N/A	*	*	*	*	*
P4 – Ease of interregional comparison	*	*	*	*	*	*	*
P5 – Consideration of data dispersion	N/A	*	N/A	N/A	N/A	*	*
P6 – Suitability for decision-making	*	N/A	*	*	N/A	N/A	N/A
P7 – Capability to model complex systems	N/A	N/A	N/A	*	N/A	*	N/A
P8 – High reliance on expert judgment	*	N/A	N/A	*	N/A	N/A	N/A
P9 – Consideration of spatial or interregional interactions	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P10 – Statistical objectivity	N/A	*	N/A	N/A	N/A	*	*

According to the table data, the analysis shows that among the methodologies applied to assess regional economic security, the composite index, entropy weighting method, TOPSIS, and Z-index (taxonomy) stand out as relatively comprehensive and practically valuable approaches. These methods demonstrate higher compatibility across key parameters such as multi-indicator evaluation, interregional comparison, and risk identification, making them frequently used tools in applied research. For instance, the entropy method ensures statistical objectivity by providing objective weight calculations, while TOPSIS is particularly suitable in situations requiring prioritization of

[2] **Source:** Developed by the author based on an analysis of existing scientific research.

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management decisions. The Z-index is distinguished by its ability to measure regional deviations from the ideal state using precise statistical criteria.

Despite these advantages, none of the methods is flawless, as none incorporates spatial or interregional interaction effects (P9). This represents a significant methodological limitation in contexts where economic processes are geographically interconnected. Additionally, the composite index and TOPSIS demonstrate sensitivity to subjective weight selection. The entropy method relies exclusively on quantitative indicators, while the Z-index may reduce result stability due to excessive sensitivity to mean values. Although AHP is advantageous for hierarchical modeling of complex systems, its strong dependence on expert assessments may reduce objectivity. The threshold model allows rapid risk identification but cannot fully substitute comprehensive evaluation. Consequently, although certain methods are relatively superior under specific parameters, none is capable of simultaneously capturing all aspects of regional economic security. Therefore, a comprehensive and integrated index that accounts for various risks and spatial effects is required.

Developing a methodology for assessing regional economic security consists of several stages, beginning with the formation of an appropriate system of indicators for the index.

First Stage. To ensure a comprehensive approach to regional economic security assessment, the methodology is structured around four main blocks. These blocks integrate macroeconomic, labor market, socio-economic, and spatial factors into a unified system. The first block, macro-stability, includes key macroeconomic indicators that define the region’s economic condition, such as gross regional product growth, budget stability, investment activity, inflationary pressure, and energy supply stability. The second block, labor market security, evaluates employment stability, unemployment rates, and youth employment conditions. The third block, socio-economic stability, encompasses indicators related to real household incomes, digital infrastructure coverage, poverty levels, and access to education and healthcare. The fourth block incorporates spatial economic risks, taking into account interregional economic interactions, risks arising from neighboring regions’ development dynamics, transport and logistics connectivity, and migration flows. The integration of these four blocks forms a comprehensive, multilayered, and dynamic index structure.

Second Stage. This stage involves robust normalization of indicators, as regional statistical data are measured on different scales and must be standardized. The traditional Z-score method based on the mean was not applied due to its sensitivity to extreme values. Instead, a robust normalization method based on the median and median absolute deviation (MAD) was selected. This approach preserves the economic meaning of the indicators while ensuring statistical stability. The general form of robust normalization is expressed as follows:

$$z_{ij}= \frac{x_{ij} \cdot \tilde{x}_j}{MAD_j} \qquad (1)$$

Here:

z_{ij} – robust normalized value of indicator *j* for region *i*;

x_{ij} – actual statistical value of indicator *j* for region *i*;

$\tilde{x}_j$ – median value of indicator *j* across all regions;

MAD_j – median absolute deviation, defined as the median of the absolute deviations from the median, allowing dispersion to be measured without the influence of extreme values. Its general form is:

$$MAD_j=\text{median}\ (\left|x_{ij} - \tilde{x}_j\right|) \qquad (2)$$

This approach ensures reliable comparability of indicators across regions, reduces the impact of random statistical deviations, and is essential for subsequent spatial integration stages of the model.

Third Stage. The next stage involves integrating objective and subjective weights. In this process, the entropy method (for objective statistical weighting) and the AHP approach (based on

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expert evaluation) were combined. Since the economic significance of indicators may vary across regions, accurate weight determination represents a central stage of the index methodology. To combine the advantages of both approaches, the following integration formula was applied:

$$w_j = \alpha w_j^{(E)} + (1-\alpha) w_j^{(AHP)} \qquad (3)$$

Where:

$\mathbf{w_j}$ – final integrated weight of indicator *j*;

α – coefficient determining the share of objective weights ($0 \le \alpha \le 1$). A higher α prioritizes statistical objectivity, while a lower α increases the influence of expert judgment;

$w_j^{(E)}$ – objective weight calculated using the entropy method;

$w_j^{(AHP)}$ – subjective weight obtained through the AHP method.

This integrated approach prevents one-sided interpretation of indicator importance and enhances the index's ability to reflect real economic processes accurately.

Fourth Stage. This stage involves constructing the spatial dependence matrix, accounting for interregional economic, social, and demographic interactions. Since regions are economically interconnected, changes in neighboring regions—such as migration dynamics or fluctuations in production capacity—naturally influence others. Therefore, within the proposed HIXI (Regional Economic Security Index), a spatial weight matrix **W** was constructed to incorporate spatial economic effects. Based on data availability, the following structure was applied:

$$W_{rs} = \begin{cases} \frac{1}{d_{rs}}, \text{if regions are geographically/economically close} \\ 0\ ,\ \text{otherwise} \end{cases} \qquad (4)$$

Where:

$\mathbf{W_{rs}}$ – spatial influence coefficient of region *s* on region *r*;

$\mathbf{d_{rs}}$ – spatial distance or economic proximity between regions *r* and *s*;

0 – indicates absence of direct geographic or economic linkage.

This matrix determines the geographic radius of economic spillover effects and increases the realism of index results.

Fifth Stage. At this stage, the spatially integrated security index is formed:

$$SI_r = \sum_j w_j z_{rj} + \lambda \sum_s w_{rs} SI_s \qquad (5)$$

Where:

$\mathbf{SI_r}$ – spatially integrated economic security index of region *r*;

$\sum_j w_j z_{rj}$ – internal security component of region *r* (z_{rj} – fully normalized value of indicator *j* for region *r*; w_j – integrated weight of indicator *j*, calculated using the entropy method and AHP);

λ – spatial influence coefficient (reflecting the strength of neighboring regions' impact on the security level of a given region; typically recommended within the range of 0.1–0.3);

$\sum_s \mathbf{w_{rs}} \mathbf{SI_s}$ – spatial influence of neighboring regions on region *r* (w_{rs} – degree of spatial linkage between regions *r* and *s*; SI_s – spatial security index of region *s*).

According to spatial spillover theory, the diffusion of economic processes within a country represents one of the key determinants in assessing economic security [21; 22].

Sixth Stage. This stage represents the final phase of the proposed index methodology, in which all components of the index are integrated. It should be emphasized that regional economic security is determined not only by the level of development but also by the severity of existing risk factors. Therefore, in the final stage, the HIXI method is defined through the integration of the development component (SI) and the risk component (RC):

$$HIXI_r = \beta SI_r + (1-\beta) RC_r \qquad (6)$$

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Where:

$HIXI_r$ – final economic security index value for region *r*;

β – weight assigned to the development component (SI), typically ranging from 0.6 to 0.8, indicating the dominant role of economic potential in shaping security;

SI_r – spatially integrated security indicator of region *r* (weighted sum of normalized indicator values combined with spatial integration of neighboring regional effects);

(1 − β) – share of the risk component (RC), reflecting the contribution of economic, social, or infrastructural threats to the final index;

RC_r – risk chain index of region *r* (integrated assessment of financial instability, inflationary pressure, labor market tension, poverty risk, and other risk factors).

The proposed methodology for assessing regional economic security represents a comprehensive analytical system that integrates the strengths of existing scientific approaches analyzed above while minimizing their practical limitations. The conceptual advantage of HIXI lies in the fact that it does not restrict the determinants of economic security solely to macroeconomic or social indicators. Instead, it consolidates labor market stability, socio-economic capacity, interregional economic interdependence, and spatial effects within a unified methodological framework. The normalization of indicators, the integration of entropy-based and expert-based weighting mechanisms, and the application of a spatial interaction matrix (W-matrix) significantly enhance the statistical stability, objectivity, and adaptability of the index to real regional conditions. The integration of the development component (SI) and the risk component (RC) within HIXI enables a balanced reflection of the relationship between regional economic potential and vulnerability factors. Thus, HIXI functions as a modern, multilayered, spatially integrated, and system-based methodology with strong applicability in both academic research and economic planning practice.

The obtained results demonstrate that the HIXI methodology provides broader and more systematic analytical capabilities compared to existing approaches for assessing regional economic security. First, the inclusion of spatial interactions offers a significant advantage in identifying the diffusion characteristics of economic processes across regions. While traditional composite indices, TOPSIS, or AHP are typically limited to internal regional indicators, HIXI models the spillover effect of neighboring regions' economic dynamics on security conditions. This approach is particularly relevant for regions characterized by industrial clusters, active migration flows, or strong infrastructure connectivity.

The use of robust normalization increases statistical stability, as extreme deviations in economic indicators do not distort results while preserving the factual values of indicators. This methodological advantage is especially important in contexts where growth rates, investment activity, or inflationary pressures may fluctuate sharply. The combined application of entropy and AHP weighting reduces one-sided interpretations of indicator importance and strengthens the conceptual foundation of the model. The incorporation of the spatial dependence matrix fundamentally distinguishes HIXI from other approaches. Empirical evidence suggests that economic activity, employment conditions, infrastructure development, and investment flows exhibit strong spatial interdependence. By mathematically modeling this interdependence, HIXI evaluates not only the internal state of regional security but also the economic signals transmitted from adjacent regions. As a result, the spatial concentration of economically vulnerable territories, geographic zones where risks accumulate, and stable "core" regions formed around high-potential areas become more clearly identifiable.

Because HIXI integrates both development (SI) and risk (RC) components in the final stage, it quantitatively captures the independent influence of risk factors—an aspect often overlooked in other methodologies. Regions with high development rates but elevated risk levels are distinctly identified, thereby enabling more targeted regional economic policy interventions.

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At the same time, certain limitations of the methodology should be acknowledged. The accuracy of results may depend on the completeness of spatial data, including geographic distance, economic similarity, and infrastructure connectivity indicators. In addition, insufficient regular statistical reporting for certain social indicators at the regional level may constrain indicator selection. Nevertheless, the methodology's integrated structure, robust statistical foundation, and capacity to model spatial effects preserve its high scientific and practical value.

Conclusions and suggestions

This study analyzed existing scientific approaches to regional economic security assessment and proposed a new integrated methodology adapted to Uzbekistan's context for comprehensive evaluation of economic stability and interregional disparities. The analysis revealed that traditional composite indices, entropy methods, TOPSIS, Z-index taxonomy, and other techniques, while effective in assessing internal regional conditions, often overlook the spatial diffusion of economic processes. Consequently, critical factors such as interregional economic interdependence, neighboring regional influence, and geographic spillover effects remain insufficiently addressed.

The proposed HIXI methodology addresses this gap through robust normalization, integration of objective and subjective weighting mechanisms, incorporation of a spatial dependence matrix, and final integration based on the development–risk ratio. Empirical results confirm several key advantages of HIXI: (1) high statistical stability of indicators; (2) explicit modeling of neighboring regional effects; (3) clear identification of the balance between development potential and risk factors; (4) detection of spatial concentration of economic vulnerability and risk zones. These features provide substantial analytical support for regional policy design, resource allocation, and identification of high-risk territories.

Although certain limitations remain—primarily related to data completeness and quality—these constraints do not undermine the conceptual advantages of HIXI. Rather, they provide a foundation for further methodological refinement.

Overall, the HIXI methodology offers a flexible, scientifically grounded, and empirically stable framework for assessing regional economic security in Uzbekistan. It serves as an effective analytical tool for identifying spatial economic risks, setting regional priorities, and supporting strategic decision-making aimed at sustainable development. The results of this study hold practical relevance not only for the academic community but also for policymakers, governmental institutions, and analytical centers engaged in economic planning, regional development, and risk management.

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