ASSESSING REGIONAL ECONOMIC SECURITY: A MULTIDIMENSIONAL FRAMEWORK BASED ON ECONOMIC DEVELOPMENT INDICATORS

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Abstract: Regional disparities in economic development require reliable tools for evaluating economic conditions across territories. This paper develops a Regional Economic Security Index (RESI) for the Republic of Karakalpakstan, twelve regions, and Tashkent City using annual data for 2010–2025 from the National Statistics Committee of the Republic of Uzbekistan. Principal Component Analysis (PCA) is applied to combine five economic indicators into a single composite measure. The first principal component explains 52.79% of the total variation and is used to construct the index. The results reveal clear regional differences, with Tashkent City, Navoi Region, and Tashkent Region recording the highest average levels of economic security, while the Republic of Karakalpakstan ranks lowest. The index also shows a gradual improvement in regional economic security over the study period. The proposed framework provides an objective measure for monitoring regional economic conditions and supporting regional development policy.

Keywords: Regional economic security; Principal Component Analysis; Composite index; Regional development; Uzbekistan.

1. INTRODUCTION

Regional disparities remain an important challenge for sustainable economic development. Differences in production, investment, employment, and business activity influence the economic capacity of regions and may lead to unequal development outcomes. Measuring these differences is therefore essential for identifying regional strengths and weaknesses and supporting evidence-based policy decisions.

In Uzbekistan, reducing regional disparities has become an important objective of economic policy. Although official statistics provide extensive information on individual economic indicators, evaluating regional economic security remains difficult because no single variable adequately reflects the overall economic position of a region. A comprehensive assessment requires combining multiple indicators into a single measure.

Previous studies have proposed various approaches to assessing regional economic security, including indicator systems, threshold values, and composite indices. However, relatively few studies have applied statistically derived composite indices to evaluate regional economic security in Uzbekistan using a consistent framework covering all fourteen first-level administrative units.

Against this background, the present study develops a Regional Economic Security Index (RESI) using Principal Component Analysis (PCA) and annual regional data for 2010–2025. The index combines indicators of economic performance, labour market conditions, investment activity, and enterprise development to provide an integrated measure of regional economic security.

2. LITERATURE REVIEW

Regional economic security has emerged as an important research area due to increasing disparities in economic development within countries. It is generally defined as the ability of a region to maintain stable economic development, efficiently utilize available resources, and withstand internal and external economic challenges. Unlike national-level assessments, regional analyses focus on identifying territorial differences in economic performance and development potential (Buyanova et al., 2019; Polukhina et al., 2026).

Many existing studies assess regional economic security using indicator systems and threshold values. However, threshold-based approaches remain controversial because benchmark values differ across regions and countries, limiting their comparability and wider application (Kalina & Savelieva, 2014).

Regional economic security is widely regarded as a multidimensional concept. Previous studies commonly assess it using indicators of economic performance, labour market conditions, investment activity, and business development. Gross regional product per capita, employment, unemployment, investment in fixed assets, and enterprise activity are among the most frequently used variables because they capture complementary aspects of regional economic development.

To combine these indicators into a single measure, researchers increasingly employ composite indices. The OECD/JRC Handbook (Nardo et al., 2008) identifies Principal Component Analysis (PCA) as one of the most widely used statistical approaches for constructing composite indicators. PCA derives weights objectively from the correlation structure of the data, reduces dimensionality, and minimizes multicollinearity while retaining most of the information contained in the original variables (Jolliffe & Cadima, 2016). Consequently, PCA has been widely applied in studies of regional development and economic security.

Although regional economic security has received increasing attention, empirical evidence for Uzbekistan remains limited. Existing studies mainly focus on conceptual frameworks or alternative assessment methods, while relatively few develop statistically derived composite indices based on Principal Component Analysis. Moreover, comprehensive assessments covering all fourteen first-level administrative units over an extended period are scarce. This study addresses these gaps by constructing a Regional Economic Security Index (RESI) for Uzbekistan using a balanced panel dataset for 2010–2025 and a PCA-based approach.

3. METHODOLOGY

3.1 Data and Variables

This study employs a quantitative research design using a balanced panel dataset covering the Republic of Karakalpakstan, 12 regions, and Tashkent City over the period 2010–2025. The dataset consists of 224 region-year observations compiled from the official statistical publications of the National Statistics Committee of the Republic of Uzbekistan (Stat.uz).

Regional economic security is assessed using five economic indicators: gross regional product (GRP) per capita, employment rate, unemployment rate, investment in fixed assets per capita, and the number of operating enterprises and organizations. These indicators were selected because they represent different dimensions of regional economic development and are consistently available for all regions throughout the study period.

GRP per capita measures regional economic performance, while the employment and unemployment rates describe labour market conditions. Investment in fixed assets per capita reflects investment activity and capital formation, whereas the number of operating enterprises and organizations represents the level of business activity. Higher values of GRP per capita, employment, investment, and enterprise activity are

considered to contribute positively to regional economic security, while a higher unemployment rate is considered to have a negative relationship with economic security.

Table 1 presents the variables used in the analysis together with their corresponding dataset variable names and the expected direction of their relationship with regional economic security.

Table 1. Variables Used in the Construction of the Regional Economic Security Index

Variable	Stata Variable	Expected Direction
Gross regional product per capita	grp_pc	+
Employment rate	emp	+
Unemployment rate	unemp	−
Investment in fixed assets per capita	inv	+
Number of operating enterprises and organizations	ent	+

Source: Compiled by the authors.

3.2 Principal Component Analysis

To construct a composite measure of regional economic security, Principal Component Analysis (PCA) was employed. PCA is a multivariate statistical technique that transforms a set of correlated variables into a smaller number of uncorrelated principal components while retaining as much of the original variation as possible. This approach reduces dimensionality and minimizes the potential influence of multicollinearity among the selected indicators.

Because the study variables are measured in different units, the analysis was performed using the correlation matrix, which standardizes the variables before extracting the principal components. Prior to conducting the PCA, the suitability of the dataset was evaluated using descriptive statistics, the correlation matrix, and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy.

The principal components were extracted according to the eigenvalue decomposition of the correlation matrix. The first principal component, which explained the largest proportion of the total variance, was selected to construct the Regional Economic Security Index (RESI). The component score for each region-year observation was obtained using the estimated PCA loadings.

The RESI was subsequently transformed into a normalized index ranging from 0 to 100 using min–max normalization:

$$\mathrm{RESI} = \frac{\mathrm{RESI_i} - \mathrm{RESI_{min}}}{\mathrm{RESI_{max}} - \mathrm{RESI_{min}}} \times 100$$

Where $\mathrm{RESI_i}$ denotes the principal component score for observation i, $\mathrm{RESI_{min}}$ and $\mathrm{RESI_{max}}$ represent the minimum and maximum values of the calculated component scores. Under this transformation, higher values indicate higher levels of regional economic security. All statistical analyses, including descriptive statistics, correlation analysis, principal component analysis, index construction, and graphical visualization, were performed using Stata 17.

4. RESULTS

4.1 Preliminary Data Assessment

Prior to the application of Principal Component Analysis (PCA), the dataset was examined using descriptive statistics, correlation analysis, and the Kaiser–Meyer–Olkin (KMO) (1974) measure of sampling adequacy. These preliminary procedures provide an overview of the characteristics of the data and assess whether the selected variables are appropriate for dimensionality reduction.

Table 2 reports the descriptive statistics for the five indicators included in the analysis. The balanced panel dataset consists of 224 region-year observations covering the Republic of Karakalpakstan, 12 regions, and Tashkent City over the period 2010–2025. The variables exhibit differences in their central tendency and dispersion, indicating sufficient variation for subsequent multivariate analysis.

Table 2. Descriptive Statistics of the Study Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
GRP per capita	224	16,783.09	20,210.77	1,572.10	152,238.20
Employment rate	224	67.67	6.00	56.00	86.90
Unemployment rate	224	6.61	2.12	3.30	11.10
Investment in fixed assets per capita	224	5,449.88	6,882.83	264.60	39,698.00
Operating enterprises and organizations	224	24,109.66	17,304.90	6,496	117,812

Source: Authors' compilation based on data from the National Statistics Committee of the Republic of Uzbekistan (Stat.uz).

The pairwise Pearson correlation coefficients are presented in Table 3. Positive and statistically significant relationships are observed among several indicators, particularly between gross regional product per capita and investment in fixed assets per capita, while unemployment displays relatively weak correlations with the remaining variables.

Table 3. Pearson Correlation Matrix

Variable	GRP per capita	Employment	Unemployment	Investment	Enterprises
GRP per capita	1.000				
Employment	0.375***	1.000			
Unemployment	0.041	-0.289***	1.000		
Investment	0.928***	0.342***	0.054	1.000	
Enterprises	0.526***	0.523***	0.073	0.523***	1.000

Source: Authors' calculations.

The suitability of the dataset for PCA was further assessed using the Kaiser–Meyer–Olkin (KMO) test. As reported in Table 4, the overall KMO value is 0.617, indicating an acceptable level of sampling adequacy. In addition, the likelihood-ratio test rejects the null hypothesis of an identity correlation matrix ($\chi^2 = 624.83$, $p < 0.001$), supporting the application of Principal Component Analysis.

Table 4. Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy

Variable	KMO
Gross regional product per capita	0.607
Employment rate	0.617
Unemployment rate	0.317
Investment in fixed assets per capita	0.602
Number of operating enterprises and organizations	0.745
Overall KMO	**0.617**

Source: Authors' calculations.

4.2 Principal Component Analysis Results

Principal Component Analysis (PCA) was applied to the five selected economic indicators using the correlation matrix to examine their underlying structure. The analysis extracted five principal components

corresponding to the five original variables. The eigenvalues and the proportion of variance explained by each component are presented in Table 5, while the scree plot is shown in Figure 1.

Table 5. Eigenvalues and Explained Variance

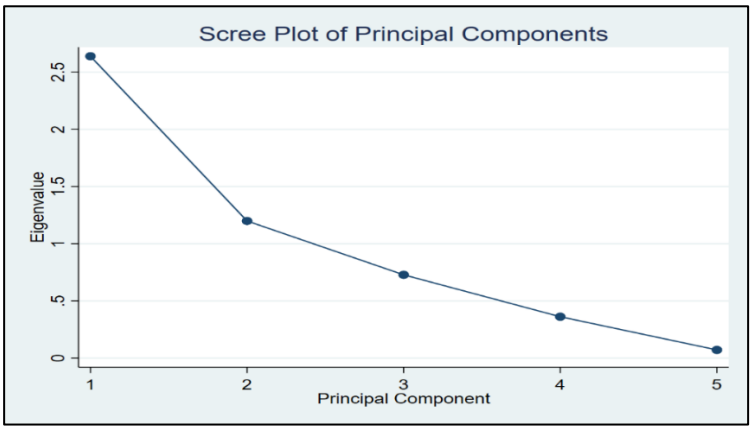
Principal Component	Eigenvalue	Variance Explained (%)	Cumulative Variance (%)
PC1	2.640	52.79	52.79
PC2	1.199	23.98	76.77
PC3	0.728	14.56	91.34
PC4	0.362	7.23	98.57
PC5	0.071	1.43	100.00

Source: Authors' calculations.

The first principal component (PC1) has an eigenvalue of 2.640 and explains 52.79% of the total variance. The second principal component (PC2) has an eigenvalue of 1.199, accounting for an additional 23.98% of the total variance. Together, the first two principal components explain 76.77% of the overall variation in the dataset. The remaining three components contribute 14.56%, 7.23%, and 1.43%, respectively (Table 5).

As illustrated in Figure 1, the eigenvalues decline sharply after the first principal component and then decrease more gradually across the remaining components. This pattern indicates that the first principal component captures the largest proportion of common variation among the selected economic indicators.

Figure 1. Scree Plot of Eigenvalues



Source: Authors' calculations.

The loadings of the first principal component are presented in Table 6. Gross regional product per capita (0.556) and investment in fixed assets per capita (0.550) have the highest positive loadings, followed by the number of operating enterprises and organizations (0.480) and the employment rate (0.398). The unemployment rate has a loading close to zero (−0.017).

Table 6. Component Loadings of the Regional Economic Security Index (PC1)

Variable	Loading
Gross regional product per capita	0.556
Investment in fixed assets per capita	0.550
Number of operating enterprises and organizations	0.480
Employment rate	0.398
Unemployment rate	−0.017

Source: Authors' calculations.

4.3 Regional Economic Security Index

The Regional Economic Security Index (RESI) was calculated for each region and year using the first principal component obtained from the principal component analysis. To facilitate interpretation and comparison, the PCA scores were normalized to a scale ranging from 0 to 100, where higher values indicate a higher level of regional economic security.

Table 7 presents the descriptive statistics of the index. The normalized RESI ranges from 0 to 100, with a mean value of 18.86 and a standard deviation of 15.40, indicating variation in regional economic security across the study period.

Table 7. Descriptive Statistics of the Regional Economic Security Index

Statistic	RESI	Normalized RESI
Observations	224	224
Mean	0.000	18.86
Standard deviation	1.625	15.40
Minimum	−1.990	0.00
Maximum	8.562	100.00

Source: Authors' calculations.

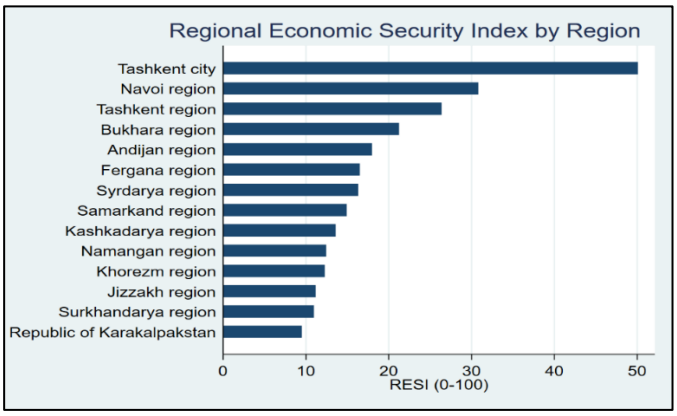
The regional distribution of the index is reported in Table 8 and illustrated in Figure 2. Tashkent City records the highest average RESI (50.07), followed by Navoi Region (30.79) and Tashkent Region (26.37). At the other end of the distribution, the Republic of Karakalpakstan records the lowest average index value (9.48). The remaining regions are distributed between these two extremes.

Table 8. Average Regional Economic Security Index by Region (2010–2025)

Rank	Region	Average RESI
1	Tashkent City	50.07
2	Navoi Region	30.79
3	Tashkent Region	26.37
4	Bukhara Region	21.23
5	Andijan Region	17.96
6	Fergana Region	16.49
7	Syrdarya Region	16.28
8	Samarkand Region	14.93
9	Kashkadarya Region	13.58
10	Namangan Region	12.43
11	Khorezm Region	12.26
12	Jizzakh Region	11.16
13	Surkhandarya Region	10.96
14	Republic of Karakalpakstan	9.48

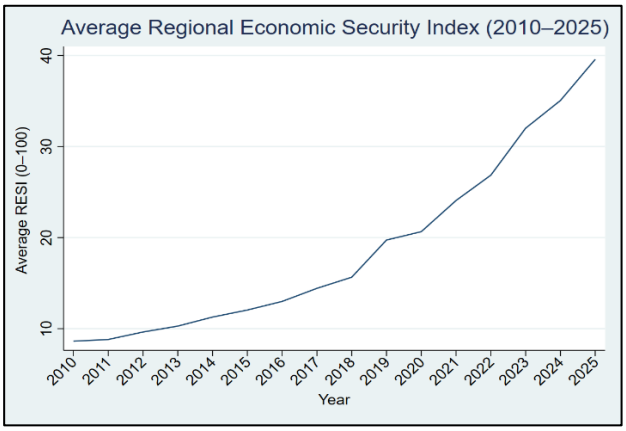
Source: Authors' calculations.

Figure 2. Average Regional Economic Security Index by Region (2010–2025).



The temporal evolution of the index is presented in Figure 3. The average RESI increased steadily from 8.63 in 2010 to 39.57 in 2025, indicating an upward movement of the index throughout the study period.

Figure 3. Trend of the Average Regional Economic Security Index, 2010–2025.



5. DISCUSSION

This study developed a Regional Economic Security Index (RESI) for Uzbekistan using Principal Component Analysis based on five economic indicators. The results indicate that the first principal component explains more than half of the total variation in the dataset, suggesting that the selected indicators capture a common dimension of regional economic security. The largest contributions to the index are provided by gross regional product per capita and investment in fixed assets, followed by enterprise activity and the employment rate, while the unemployment rate contributes relatively little to the first principal component.

The Regional Economic Security Index reveals substantial disparities across the fourteen administrative units of Uzbekistan. Tashkent City records the highest average RESI value during the study period, followed by Navoi Region and Tashkent Region. These regions consistently demonstrate stronger economic performance, characterized by higher gross regional product per capita, greater investment activity, and a larger number of operating enterprises. The combined effect of these indicators results in higher overall economic security scores.

At the opposite end of the distribution, the Republic of Karakalpakstan records the lowest average RESI value, while Surkhandarya, Jizzakh, and Khorezm also remain below the national average. Compared with the leading regions, these territories generally exhibit lower levels of economic output, investment in fixed assets, and business activity, resulting in lower composite index values. The remaining regions

occupy intermediate positions, reflecting differences in the overall combination of economic indicators rather than the influence of any single variable.

These findings demonstrate that regional economic security is unevenly distributed across Uzbekistan. The observed differences suggest that stronger regional economic security is associated with a combination of higher production capacity, greater investment, and more intensive business activity. Therefore, evaluating regional economic security through a composite index provides a more comprehensive assessment than relying on individual economic indicators alone.

The temporal analysis further shows a steady increase in the average RESI between 2010 and 2025. This upward trend indicates a gradual improvement in the overall economic conditions represented by the selected indicators throughout the study period. Although the pace of improvement differs across regions, the results suggest that regional economic security generally strengthened over time.

The findings are consistent with previous studies that view regional economic security as a multidimensional concept requiring the integration of several economic indicators. They also support earlier research demonstrating the usefulness of composite indices for evaluating regional disparities.

Unlike studies based on expert-defined weights or threshold values, this study employs Principal Component Analysis to derive indicator weights objectively from the statistical properties of the data. This approach reduces subjectivity and provides a transparent and replicable framework for assessing regional economic security using official regional statistics.

The Regional Economic Security Index provides a practical tool for monitoring regional economic conditions and identifying territorial disparities. The findings suggest that strengthening investment activity, expanding enterprise development, and improving regional economic performance remain important priorities for reducing regional inequalities. The index can also support policymakers in evaluating regional development strategies and monitoring changes in regional economic security over time.

This study has several limitations. First, the index is constructed exclusively from economic indicators and does not include social, environmental, or institutional dimensions of regional development. Second, the results depend on the selected variables and the assumptions underlying Principal Component Analysis. Future research may expand the indicator set and compare PCA with alternative methods for constructing composite indices to evaluate the robustness of the results.

6. CONCLUSION

This study developed a Regional Economic Security Index (RESI) for the fourteen first-level administrative units of Uzbekistan using Principal Component Analysis and official regional statistics for the period 2010–2025. By combining five economic indicators into a single composite measure, the study provides a consistent framework for assessing regional economic security and comparing regional performance over time. The index reveals noticeable differences in economic security across regions, with Tashkent City, Navoi Region, and Tashkent Region achieving the highest average scores, while the Republic of Karakalpakstan records the lowest. The temporal analysis also points to a gradual improvement in regional economic security during the study period, although the extent of progress varies across regions. The proposed index offers an objective and replicable approach for monitoring regional economic conditions and identifying territorial disparities. Future research may broaden the assessment by incorporating social, environmental, and institutional indicators and by comparing Principal Component Analysis with alternative methods for constructing composite indices.

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