ECONOSCITECH INTEGRATION

ISSUE 10 PART II

INTERNATIONAL SCIENTIFIC ELECTRONIC JOURNAL

TASHKENT STATE UNIVERSITY OF ECONOMICS

American University of Technology
Powered by Arizona State University®

ISSN: 3060-5075



Acceptance of articles
PUBLISHED MONTHLY

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ISSN INTERNATIONAL STANDARD SERIAL NUMBER DENMARK

CONTACT: +998 94 3540880 https://econoscitech-integration-journal.uz

2026



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In accordance with Resolution No. 384/6 dated April 10, 2026, issued by the Presidium of the Supreme Attestation Commission under the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan, this journal is included in the list of recommended international scientific publications for publishing the primary research findings of doctoral dissertations in the field of Economic Sciences.

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Electronic publication. Issue 10. PART II
500 pages. Approved for publication in October 2026.

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INTEGRATED STATISTICAL ASSESSMENT AND ECONOMETRIC MODELLING OF BUSINESS DEVELOPMENT ACROSS THE REGIONS OF UZBEKISTAN

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Abstract. This article develops an integrated framework for assessing regional business development in Uzbekistan by combining a multidimensional relative index with panel econometric modelling. The empirical analysis uses 22 financial, production, resource, investment, employment, and export indicators for 14 regions in 2023–2024, together with a balanced panel comprising 210 region-year observations for 2010–2024. The regional index is constructed using z-standardised indicators and is employed to compare dispersion, changes in regional rankings, and the relative positions of regions. The standard deviation of the index increased from 0.2963 in 2023 to 0.3527 in 2024, while the interquartile range rose from 0.1970 to 0.3367, indicating increasing regional differentiation. For the longer period, a logarithmic fixed-effects model examines the relationship between business output and investment, construction, household income, employment, and exports. The largest conditional elasticities are associated with household income and employment. The findings demonstrate that a single regional ranking is insufficient for policy evaluation: relative indices should be interpreted alongside absolute indicators, structural characteristics, and econometric diagnostics. The proposed framework can support differentiated regional policies and more transparent monitoring of business development.

Keywords: business development, regional disparities, integral index, panel data, fixed effects, econometric modelling, Uzbekistan.

Аннотация. В статье разработан интегрированный подход к оценке регионального развития бизнеса в Узбекистане, объединяющий многомерный относительный индекс и эконометрическое моделирование панельных данных. Эмпирическая база включает 22 финансовых, производственных, ресурсных, инвестиционных, трудовых и экспортных показателя по 14 регионам за 2023–2024 годы, а также сбалансированную панель из 210 наблюдений «регион–год» за 2010–2024 годы. Региональный индекс формируется на основе z-стандартизированных показателей и используется для сопоставления вариации, изменений региональных рейтингов и относительного положения регионов. Стандартное отклонение индекса увеличилось с 0,2963 в 2023 году до 0,3527 в 2024 году, а межквартильный размах - с 0,1970 до 0,3367, что свидетельствует об усилении региональной дифференциации. Для анализа более длительного периода используется логарифмическая модель с фиксированными эффектами, отражающая взаимосвязь между объёмом выпуска бизнеса и инвестициями, строительством, доходами населения, занятостью и экспортом. Наибольшие условные эластичности выявлены для доходов населения и занятости. Результаты показывают, что региональный рейтинг необходимо интерпретировать в совокупности с абсолютными показателями, структурными характеристиками и результатами эконометрической диагностики. Предложенный подход может способствовать формированию дифференцированной региональной политики и повышению прозрачности мониторинга развития бизнеса.

Ключевые слова**:** развитие бизнеса, региональная дифференциация, интегральный индекс, панельные данные, фиксированные эффекты, эконометрическое моделирование, Узбекистан.

INTRODUCTION

Assessing business development across regions is a multidimensional statistical task. Profit, revenue, costs, investment, assets, employment, and exports reflect different aspects of business activity, while absolute indicators may systematically favour larger regional economies. A robust regional assessment therefore requires both relative and structural perspectives. A composite index can summarise the position of each region across multiple indicators, whereas panel econometric modelling can identify systematic relationships between business output and its major correlates over time.

Regional differences in business development are shaped by variations in economic structure, investment activity, labour market conditions, and access to financial and productive resources. These factors influence the capacity of regional economies to support business operations, generate employment, and expand production. Consequently, evaluating regional business development solely through individual economic indicators may provide an incomplete picture of underlying patterns. An integrated statistical approach allows multiple dimensions of business activity to be examined simultaneously, making it possible to identify regional strengths, structural differences, and areas requiring additional policy attention.

The application of econometric methods further strengthens regional analysis by examining the relationships between business performance and its associated economic factors over an extended period. Panel data models are particularly useful in this context because they combine cross-regional and temporal information while accounting for unobserved regional characteristics. Integrating statistical indices with econometric estimates also provides an opportunity to assess whether changes in relative regional positions correspond to broader patterns of investment, employment, household income, and external economic activity. Such an approach can contribute to more consistent regional comparisons and support the development of differentiated economic policies based on measurable characteristics.

The purpose of this article is to evaluate relative differences in business development across 14 regions of Uzbekistan using a 22-indicator framework and to examine the longer-term associations between business output and key regional factors using a balanced panel of 210 observations for 2010–2024. Combining these two approaches makes it possible to distinguish changes in relative regional positions from broader relationships involving investment, construction, income, employment, and exports.

LITERATURE REVIEW

Multivariate statistical analysis commonly relies on standardisation and aggregation to represent complex economic phenomena through composite indicators. The approach associated with Aivazyan emphasises normalisation, comparability, and consideration of correlations among indicators. International practice, including the OECD SME Policy Index, demonstrates the usefulness of multidimensional indicators for policy monitoring and cross-regional comparisons. At the same time, composite indices are sensitive to indicator selection, scaling, and weighting and therefore should not be interpreted as direct measures of absolute economic growth.

The methodological literature also highlights the importance of distinguishing between the statistical comparability of indicators and their economic interpretation. Standardisation makes it possible to combine variables measured in different units, while aggregation provides a generalised representation of regional business development. However, the resulting index depends on the structure of the underlying dataset and the relative contribution of individual indicators. In this context, the principles of multivariate statistical analysis discussed by Aivazyan provide a methodological basis for examining the relationships among indicators and ensuring consistency in regional comparisons. The OECD's multidimensional approach further supports the use of composite indicators as monitoring instruments, particularly when aggregate assessments are supplemented by information on individual dimensions of economic performance.

Panel-data econometrics provides a complementary perspective. Wooldridge and Greene demonstrate that fixed-effects models can account for time-invariant characteristics of observational units that might otherwise bias pooled estimates. In applied research, pooled ordinary least squares (OLS), fixed-effects (FE), and random-effects (RE) models are often compared using specification tests, including the F-test, Breusch–Pagan Lagrange multiplier (LM) test, and Hausman test. The combined use of a regional index and panel models is valuable because the former captures relative regional positions, while the latter helps identify persistent statistical associations across regions and over time.

An important methodological consideration in panel econometric research concerns the interpretation and reliability of estimated relationships. As reflected in the econometric frameworks presented by Wooldridge and Greene, model selection should account for unobserved heterogeneity, the statistical properties of explanatory variables, and the assumptions underlying alternative estimation methods. Fixed-effects specifications are

particularly relevant when regional characteristics remain relatively stable over time and may be correlated with the included regressors. Nevertheless, the interpretation of estimated coefficients requires attention to potential multicollinearity, endogeneity, and common time-related influences. Accordingly, combining panel estimation with appropriate specification tests and diagnostic procedures provides a stronger analytical foundation for examining the relationships between business development and regional economic factors.

RESEARCH METHODOLOGY

The first stage uses 22 financial and economic indicators for 14 regions in 2023–2024. Each indicator is standardised using the formula $z_{hjt} = (x_{hjt} - \bar{x}_{jt}) / s_{jt}$, where h denotes the region, j denotes the indicator, and t denotes the year. Indicators with an adverse direction are adjusted so that higher standardised values consistently reflect a more favourable business position. The resulting composite index is a relative measure: because indicators are standardised separately for each year, the index describes a region's position relative to the cross-regional distribution in that year. For comparisons over time, fixed-base standardisation using a common mean and standard deviation is preferable.

The second stage uses a balanced panel of 14 regions over 2010–2024, comprising 210 region-year observations. Business output is treated as the dependent variable, while the explanatory variables include the number of active business entities, investment, construction, wholesale trade, household income, employment, and exports. Logarithmic specifications based on pooled ordinary least squares (OLS), fixed effects (FE), and random effects (RE) are compared. The available specification tests support the FE model as the preferred working specification. The coefficients are interpreted as conditional associations rather than causal effects, as endogeneity, cross-sectional dependence, and common macroeconomic shocks require separate identification and robustness analyses.

Artificial intelligence (AI) tools were used to a limited extent, accounting for approximately 10% of the overall research preparation process. Their use was primarily confined to language refinement, technical editing, and structural support. The selection of research methods, analysis and interpretation of findings, formulation of scientific conclusions, and development of recommendations were carried out independently by the author. The author assumes full responsibility for the accuracy, originality, and scientific integrity of the research.

ANALYSIS AND RESULTS

The composite index reveals substantial changes in relative regional positions. Tashkent city increased from 0.5400 in 2023 to 0.6895 in 2024, while Navoi rose from 0.4742 to 0.6454 and remained among the leading regions. Bukhara recorded the largest positive change, increasing from −0.4080 to 0.4545. In contrast, Samarkand's index value decreased from 0.4874 to −0.1131. These values should be interpreted as changes in relative positions within the annual cross-sectional distribution rather than as direct measures of absolute output growth (Table 1).

Table 1
Main dispersion indicators of the regional integral index[1]

Indicator	2023	2024
Standard deviation	0.2963	0.3527
Median	-0.0656	-0.1212
IQR	0.1970	0.3367
Skewness	0.7195	0.8950

The standard deviation increased from 0.2963 to 0.3527, while the interquartile range rose from 0.1970 to 0.3367. Both changes indicate greater regional dispersion in 2024. The increase in skewness to 0.8950 also suggests that a small group of high-performing regions became more distinct from the rest of the distribution. For policy analysis, the aggregate index is therefore more informative when supplemented by sub-indices covering financial performance, assets, investment and employment, and external economic activity.

In the panel dataset, the pairwise correlation between business output and construction is r = 0.92, while the correlation between business output and investment is r = 0.90. These strong relationships are economically significant, but they also increase the potential risk of multicollinearity. A reduced five-factor fixed-effects (FE)

1 Author's development.

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specification retains investment, construction, household income, employment, and exports as explanatory variables (Table 2).

Table 2
Conditional elasticities in the five-factor fixed-effects specification[2]

Factor	β	Associated difference in Y for 1% higher X
Investment	0.0495	≈0.05%
Construction	0.1296	≈0.13%
Household income	1.0269	≈1.03%
Employment	0.7062	≈0.71%
Exports	0.0172	≈0.02%

Household income and employment have the largest coefficients in the reduced specification. Holding other included factors constant, a 1% increase in household income is associated with an approximately 1.03% increase in business output, while a 1% increase in employment is associated with an approximately 0.71% increase in output. The elasticities for investment and exports are smaller. These estimates should not be interpreted as direct policy multipliers, as causal interpretation would require stronger identification. Cross-sectional dependence, price effects, and potential endogeneity also remain important methodological considerations.

Combining the integral index with the panel model provides a more comprehensive assessment than simply classifying regions as having “high” or “low” levels of business development. The index captures relative positions across a broad set of indicators, while the econometric model summarises longer-term conditional associations. Presenting absolute economic indicators, relative index values, and factor profiles alongside one another helps distinguish economic scale from performance and identify the structural factors underlying changes in regional rankings.

Changes in the composite index must also be distinguished from changes in absolute economic scale. For example, Bukhara’s substantial improvement in the relative index does not necessarily imply that all business indicators increased at the same rate; it may reflect faster improvements in selected indicators alongside simultaneous changes in other regions. Similarly, Samarkand’s lower relative score does not, in itself, indicate a contraction in business activity. A more comprehensive interpretation requires comparisons with absolute output, investment, employment, productivity, and per capita indicators.

The panel specification should likewise be regarded as an analytical framework rather than a directly applicable causal policy formula. The comparatively high coefficients for household income and employment indicate a close relationship between domestic demand, labour market conditions, and business output. However, the effects of specific policy interventions require separate identification. Future research should examine the model using constant-price series, common time effects, robust standard errors accounting for cross-sectional dependence, alternative dynamic panel specifications, and out-of-sample validation.

CONCLUSION AND RECOMMENDATIONS

The results indicate that regional differentiation in business development increased between 2023 and 2024 and that a single regional ranking is insufficient for informed policy decisions. The observed increase in the standard deviation and interquartile range of the composite index reflects greater variation in the relative positions of Uzbekistan’s regions. These findings highlight the importance of adopting a multidimensional approach that considers not only aggregate regional performance but also the underlying financial, investment, employment, and structural characteristics of business activity.

The relative index captures changes in regional positions across multiple indicators, while the fixed-effects panel model identifies longer-term conditional relationships between business output and household income, employment, investment, construction, and exports. The comparatively high elasticities associated with household income and employment suggest that domestic demand and labour market conditions are closely related to regional business development. However, these relationships should be interpreted as statistical associations rather than direct causal effects. Integrating the two analytical approaches provides a more comprehensive basis for understanding regional differences and identifying priorities for economic development.

2 Author’s development.

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Based on these findings, five recommendations are proposed: (1) publish the aggregate index alongside thematic sub-indices to provide a more detailed assessment of regional business performance; (2) apply fixed-base standardisation when comparing changes over time to ensure greater consistency and comparability; (3) differentiate regional support programmes according to the composition of the index and the factor profile of each region, taking into account their specific economic characteristics; (4) strengthen panel models through robust statistical inference, common time effects, and endogeneity checks to improve the reliability of econometric estimates; and (5) maintain metadata passports for each indicator, specifying its source, unit of measurement, price base, and classification version to ensure methodological transparency and consistency.

Overall, the proposed integrated framework offers a systematic approach to assessing regional business development by combining multidimensional statistical indicators with panel econometric analysis. Its practical application can support more differentiated regional policies, facilitate the identification of changes in business development patterns, and improve the transparency and consistency of regional economic monitoring. Further refinement of the framework through additional robustness checks and improvements in statistical comparability can strengthen its usefulness for evidence-based regional policy formulation and the long-term assessment of business development across Uzbekistan.

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INTERNATIONAL SCIENTIFIC ELECTRONIC JOURNAL

Proofreader: Xondamir Ismoilov

Layout and Designer: Hasan Maqsudov

2026. № 10/2

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