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INTEGRATED ASSESSMENT OF THE STRUCTURAL DEVELOPMENT OF THE ENTREPRENEURSHIP SECTOR IN UZBEKISTAN USING AN AHP–ENTROPY–TOPSIS MODEL

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Abstract
This article proposes a multi-criteria integral model based on the AHP–Entropy–TOPSIS framework to assess the structural development of the entrepreneurship sector across Uzbekistan's regions. Fourteen indicators are grouped into quantitative-structural, innovation, institutional and territorial-balance blocks. AHP captures expert priorities, Shannon entropy provides an objective statistical weighting component, and TOPSIS ranks regions according to their proximity to the ideal solution. The AHP weights are 0.357 for innovation, 0.335 for territorial balance, 0.198 for quantitative-structural factors and 0.110 for the institutional environment. Using official data for the first quarter of 2026, Tashkent city records the highest closeness coefficient (CC=0.812), followed by Tashkent region (0.724), while Syrdarya has the lowest value (0.386). Compared with monocriteria assessment, the model improves the identification of structural imbalances by functional block and supports differentiated regional policy.

Keywords: Entrepreneurship sector, integral assessment, AHP, Shannon entropy, TOPSIS, multi-criteria decision making, regional development, HHI, diversification.

Introduction

Assessing regional entrepreneurship development solely by the number of firms, their share in gross regional product or employment does not fully capture the internal structural quality of the economic system. A region may have many entrepreneurs, yet if innovation activity is weak, sectoral diversification is limited or institutional costs are high, its long-term structural sustainability may remain constrained. This creates a need for a multi-criteria integral assessment of the entrepreneurship sector.

Multi-criteria decision-making (MCDM) methods make it possible to combine indicators measured in different units into a unified ranking system. The Analytic Hierarchy Process (AHP), developed by Thomas Saaty, determines the relative importance of criteria through expert pairwise comparisons; Shannon entropy assigns objective weights based on statistical dispersion; and TOPSIS, introduced by Hwang and Yoon, ranks alternatives according to their proximity to an ideal solution. Integrating these methods creates a framework that balances expert judgment with statistical information.

The purpose of this article is to present a methodology for the integral assessment of structural entrepreneurship development across the regions of Uzbekistan using 14 indicators grouped into four functional blocks, and to analyze the experimental results obtained from data for the first quarter of 2026.

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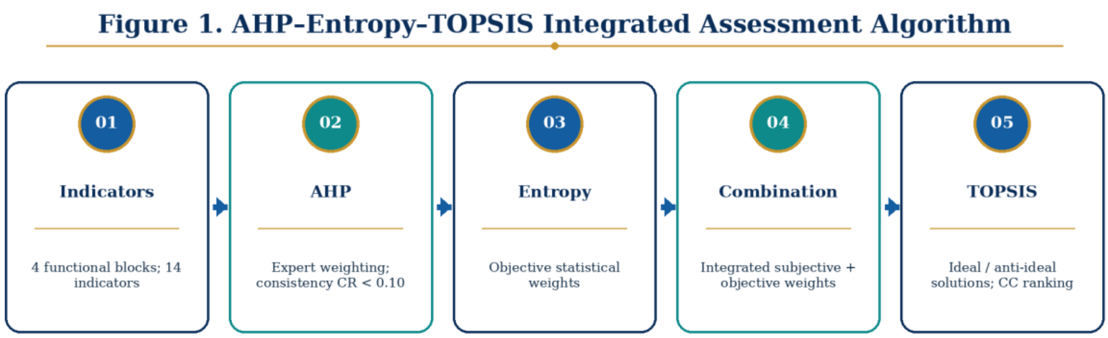

Figure 1. AHP–Entropy–TOPSIS integrated assessment algorithm

Indicator System and Functional Blocks

The integral model divides 14 indicators of structural entrepreneurship development into four blocks: A – quantitative-structural indicators; B – innovation development; C – institutional environment; and D – territorial balance. For Max-type indicators, higher values are interpreted as favorable; for Min-type indicators, lower values are favorable. Including HHI and Theil indices enables the model to assess not only the scale of the sector but also the quality of diversification and territorial equality.

Table 1. Indicator system of the integral assessment model

Code	Indicator	Unit	Direction	Block
A1	Number of MSME entities	Thousand	Max	A
A2	Share of MSMEs in GDP	Percent	Max	A
A3	Sectoral HHI index	Index	Min	A
A4	Diversification index D=1−HHI	Index	Max	A
B1	Share of innovation-active enterprises	Percent	Max	B
B2	Share of the ICT sector in GDP	Percent	Max	B
B3	Number of patents and licenses	Units	Max	B
B4	R&D expenditure as a share of GDP	Percent	Max	B
C1	Business registration time	Days	Min	C
C2	Difficulty-of-credit-access index	Score	Min	C
C3	Number of tax payments	Units	Min	C
D1	Territorial HHI distribution index	Index	Min	D
D2	Share of rural entrepreneurship	Percent	Max	D
D3	Theil index	Index	Min	D

Determining Expert Weights with AHP

At the AHP stage, the four blocks are compared pairwise using Saaty's scale. A value of 1 denotes equal importance, 3 moderate preference, 5 strong preference, 7 very strong preference

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and 9 extreme preference; intermediate values are represented by 2, 4, 6 and 8. After normalization of the pairwise comparison matrix, the average of each row provides the priority weight of the corresponding block.

The innovation-development block receives the largest weight, 0.357. Territorial balance ranks second at 0.335, followed by the quantitative-structural block at 0.198 and the institutional environment at 0.110. These results indicate that qualitative renewal of entrepreneurship and interregional balance are treated as the central criteria of the model. Consistency of AHP judgments is controlled through the condition CR<0.10.

Table 2. AHP pairwise comparison matrix and block weights

Block	A	B	C	D	AHP weight
A – Quantitative-structural	1	0.5	2	1	0.198
B – Innovation	2	1	3	2	0.357
C – Institutional	0.5	0.33	1	0.5	0.110
D – Territorial balance	1	0.5	2	1	0.335

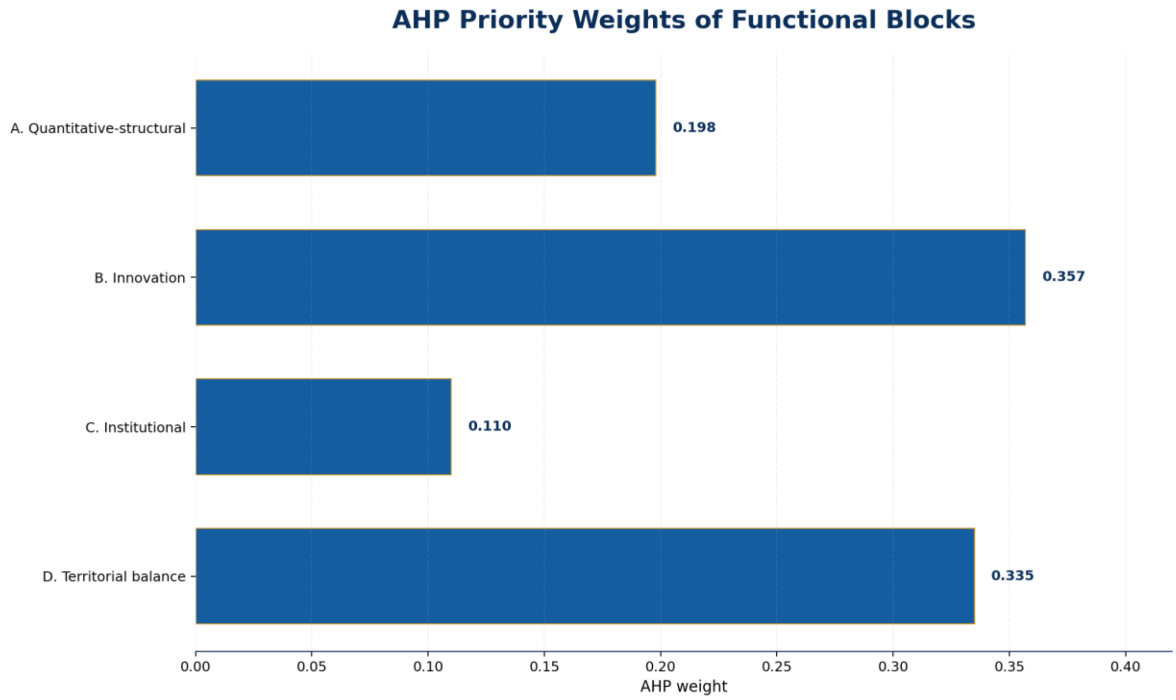

Figure 2. AHP weights of the functional blocks

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Entropy and Combined Weighting

Shannon entropy balances the expert-dependent subjective component of AHP with statistical information. The greater the variation of an indicator across regions, the higher its information content and the larger its objective weight. The decision matrix is first normalized, after which probability shares and entropy values are calculated for each indicator.

In the entropy approach, as e_j approaches 1, interregional variation in the corresponding indicator decreases. The divergence coefficient $d_j=1-e_j$ represents the discriminatory information capacity of the indicator. In the final model, subjective AHP weights and objective entropy weights are combined according to the integration algorithm specified in the dissertation, producing composite weights in which expert priorities are validated against statistical dispersion.

$e_j = -k \sum p_{ij} \ln(p_{ij})$, $d_j = 1 - e_j$, $w_j^E = d_j / \sum d_j$

TOPSIS Algorithm

At the TOPSIS stage, all regions are assessed using the combined weights. Indicators are first vector-normalized and a weighted decision matrix is then obtained. Positive and negative ideal solutions are determined for each indicator. For Max-type indicators, the maximum is treated as the positive ideal; for Min-type indicators, the minimum is treated as the positive ideal.

The Euclidean distance of each region from the ideal and anti-ideal solutions is then calculated, and the final closeness coefficient (CC) is determined. As CC approaches 1, the region is interpreted as being closer to the ideal state of structural development.

$S_i^+ = \sqrt{\Sigma(v_{ij} - v_j^+)^2}$, $S_i^- = \sqrt{\Sigma(v_{ij} - v_j^-)^2}$

$CC_i = S_i^- / (S_i^+ + S_i^-)$, $0 \le CC_i \le 1$

Empirical Results: First Quarter of 2026

Experimental calculations were conducted for 14 regions using official statistics for January–March 2026. The indicators were standardized and entered into the TOPSIS algorithm using weights derived from AHP and entropy. Tashkent city ranked first with CC=0.812, followed by Tashkent region with 0.724. Samarkand (0.671), Fergana (0.648), Andijan (0.621) and Khorezm (0.603) occupied the upper part of the middle group.

Table 3. Selected TOPSIS ranking results for Uzbekistan's regions, Q1 2026

Rank	Region	CC	A/B/C/D profile	Level
1	Tashkent city	0.812	0.91/0.84/0.79/0.71	High
2	Tashkent region	0.724	0.79/0.72/0.70/0.63	High
3	Samarkand	0.671	0.74/0.59/0.68/0.73	Medium
4	Fergana	0.648	0.71/0.56/0.66/0.70	Medium
5	Andijan	0.621	0.69/0.54/0.63/0.67	Medium
10	Surkhandarya	0.473	0.49/0.36/0.50/0.54	Low
11	Jizzakh	0.441	0.45/0.33/0.47/0.51	Low
12	Karakalpakstan	0.418	0.43/0.31/0.45/0.49	Low
13	Navoi	0.401	0.41/0.28/0.44/0.46	Low
14	Syrdarya	0.386	0.39/0.26/0.42/0.44	Low

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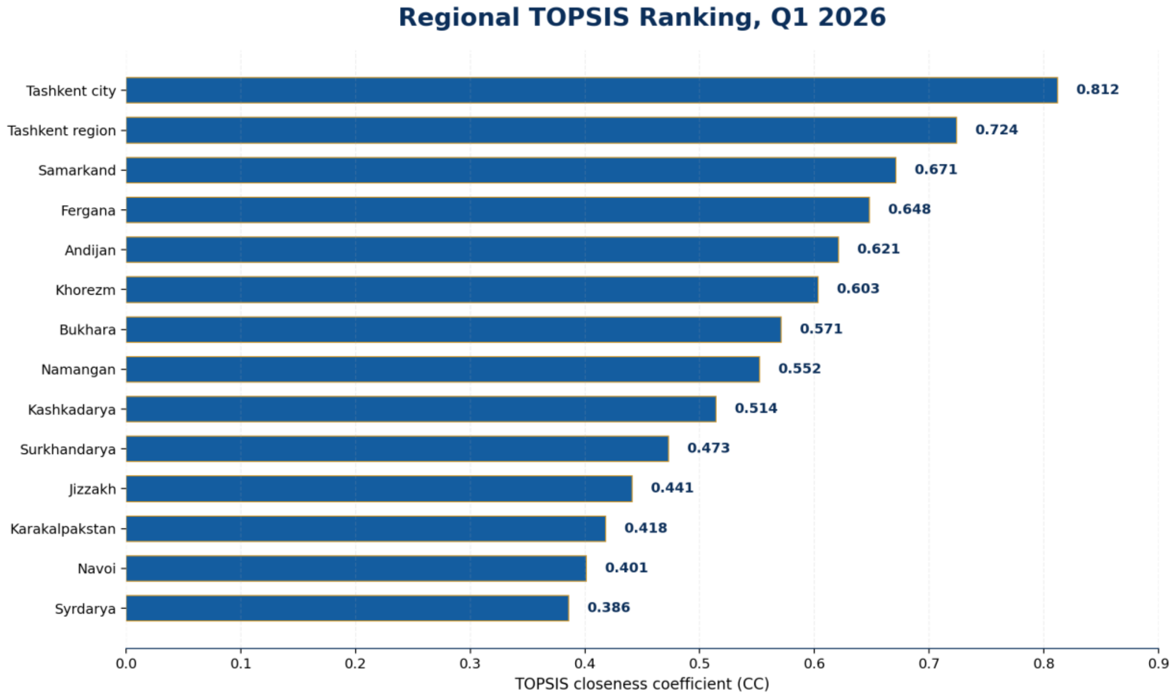

Figure 3. Regional ranking by TOPSIS closeness coefficient

Tashkent city's high score is explained by comparatively strong values across all four blocks: 0.91 for block A, 0.84 for block B, 0.79 for block C and 0.71 for block D. In particular, strong innovation and institutional components complement the capital city's business infrastructure, digital services and market capacity.

The lower-performing group includes Surkhandarya (0.473), Jizzakh (0.441), the Republic of Karakalpakstan (0.418), Navoi (0.401) and Syrdarya (0.386). In Syrdarya, block B equals 0.26 and block A equals 0.39, indicating weakness in innovation activity and quantitative-structural capacity. Navoi also records a low block-B score of 0.28; this demonstrates that the dominance of large-scale industry does not automatically generate a diversified and innovation-oriented small-business base.

A key advantage of the model is that even regions with similar overall CC values can be diagnosed according to the specific source of weakness. If territorial balance is high but the innovation block is weak, policy should emphasize technological renewal and innovation finance; if the institutional block is weak, the priority should be to reduce administrative burdens and barriers to financial access.

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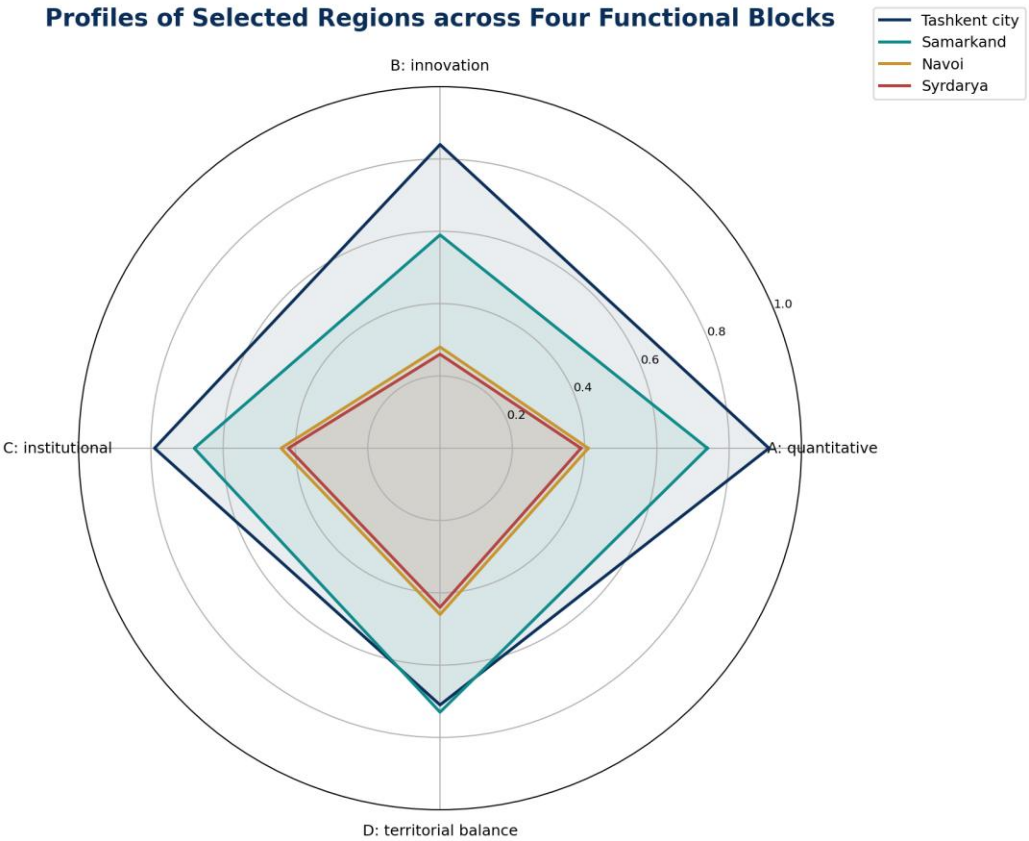

Figure 4. Profiles of selected regions across the four functional blocks

Comparative Analysis of Monocriteria and Integral Approaches

Table 4. Comparison of monocriteria and integral assessment approaches

Criterion	Monocriteria approach	Integral model
Assessment base	1–2 separate indicators	Multi-criteria system in 4 blocks
Methodological basis	Simple statistical comparison	AHP–Entropy–TOPSIS
Weighting	Equal/conditional weights	Expert + objective statistical weights
Regional differentiation	Limited	High-resolution differentiation
Structural imbalances	Not fully identified in practice	Identified by functional block
Innovation component	Insufficiently considered	Separate innovation block B
Monitoring	Fragmented	Periodic algorithmic monitoring possible
Policy decisions	General description	Targeted and differentiated policy

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Under monocriteria rankings, a region with a large number of firms may automatically be classified as developed. The integral model simultaneously accounts for scale, innovation, institutions and territorial balance. This allows resources to be allocated not as a punitive response to rankings, but as targeted development support based on the identified weak block.

Reliability, Limitations and Sensitivity of the Model

The main limitation of AHP is its dependence on expert judgment. Therefore, consistency of pairwise comparisons should be verified using CR<0.10, while the expert panel should include specialists in economics, entrepreneurship, statistics and regional governance. The entropy method reduces subjectivity, although in datasets with very limited dispersion it may produce similar weights across indicators.

TOPSIS relies on Euclidean distance and does not directly capture complex nonlinear relationships among indicators. Sensitivity analysis can therefore be strengthened by varying weights by ±10%, applying alternative normalization schemes, and comparing results with methods such as the Best-Worst Method or VIKOR. The dissertation methodology likewise recommends testing model robustness through weight sensitivity.

The Q1 2026 results represent a short-period experimental cross-section. They should not be interpreted as long-term structural trends before the calculations are repeated using annual and multi-year data. Nevertheless, the block-based architecture is well suited to a monitoring platform and can support quarterly and annually updated ranking systems.

Conclusion

The proposed AHP–Entropy–TOPSIS model enables comprehensive assessment of structural entrepreneurship development using 14 indicators grouped into four functional blocks. AHP captures expert priorities, entropy represents objective statistical differentiation, and TOPSIS measures regional proximity to the ideal state within a unified algorithm.

The innovation block (0.357) and territorial balance (0.335) receive the highest AHP weights. In the Q1 2026 test, Tashkent city (CC=0.812) and Tashkent region (CC=0.724) form the leading group, while Syrdarya records the lowest score (CC=0.386). The findings show that entrepreneurship policy should move beyond firm counts and toward differentiated management based on innovation quality, the institutional environment and territorial balance.

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