AMERICAN JOURNAL OF MULTIDISCIPLINARY BULLETIN
ISSN: 2996-511X (online) | ResearchBib (IF) = 9.512 IMPACT FACTOR
Volume-3| Issue-10| 2025 Published: |30-11-2025|

IMPROVING THE PLACEMENT OF INDUSTRIAL COMPLEXES IN BUKHARA REGION: A SPATIAL-ECONOMIC ANALYSIS

https://doi.org/10.5281/zenodo.17785421

Kudratov Muhammad Rustamovich
Doctoral Student
Bukhara State Technical University

Abstract

This study investigates the optimization of industrial complex placement in Bukhara region, Uzbekistan, utilizing Weber's industrial location theory and contemporary spatial-economic analysis frameworks. The research employs a mixed-methods approach combining quantitative analysis of industrial indicators with qualitative assessment of locational factors. Results demonstrate that Bukhara region possesses significant competitive advantages in gas chemical, textile, and petroleum refining industries due to natural resource endowments and strategic transport positioning. The study identifies that the Karakul Free Economic Zone represents an optimal agglomeration model, with projected polymer production capacity of 730,000 tons annually. Key findings reveal that transport cost optimization, labor availability, and agglomeration economies are the primary determinants of industrial location efficiency. The research contributes to regional development policy by proposing a comprehensive framework for industrial spatial planning that balances economic efficiency with sustainable development objectives.

Keywords

Industrial location, Bukhara region, Weber's theory, Free Economic Zone, spatial planning, agglomeration economies

The strategic placement of industrial complexes constitutes a fundamental pillar of regional economic development, particularly in emerging economies undergoing structural transformation. Uzbekistan, as Central Asia's most populous nation with significant natural resource endowments, has undertaken comprehensive industrial policy reforms since 2017 to diversify its economy and enhance value-added production. The Bukhara region, situated in southwestern Uzbekistan, occupies a pivotal position in this transformation owing to its substantial hydrocarbon reserves, strategic transport corridors, and historical economic significance.

Over the past eight years, Bukhara region has attracted more than $8 billion in investments, resulting in the establishment of approximately 6,000 new industrial enterprises and a sixfold increase in industrial production volume. The region's transformation from a predominantly agricultural economy to an industrial-service hybrid model necessitates rigorous scientific analysis of optimal industrial placement strategies. This imperative is particularly acute given the government's establishment of the Karakul Free Economic Zone and the ongoing construction of the $3.1 billion MTO Gas Chemical Complex, which will produce 1.1 million tonnes of polymer materials upon completion.

Despite substantial investment inflows and policy support, the spatial distribution of industrial enterprises in Bukhara region remains suboptimal, characterized by concentration in urban centers and underutilization of peripheral districts with significant resource potential. The current industrial placement pattern reflects historical legacy factors rather than contemporary optimization principles, resulting in elevated transport costs, labor market imbalances, and insufficient agglomeration benefits. Furthermore, the integration of traditional location theory with modern spatial planning requirements presents methodological challenges that require systematic investigation. The primary objective of this research is to develop a scientifically-grounded framework for optimizing industrial complex placement in Bukhara region. Specific objectives include: (1) analyzing the current spatial distribution of industrial enterprises and identifying efficiency gaps; (2) evaluating locational factors affecting industrial placement decisions using Weber's least-cost theory and contemporary agglomeration economics; (3) assessing the role of Free Economic Zones in industrial cluster formation; and (4) formulating evidence-based recommendations for improving industrial spatial planning. This research contributes to both theoretical understanding and practical policy formulation in regional industrial development. Theoretically, the study extends classical location theory by incorporating institutional factors and cluster dynamics specific to transition economies. Practically, the findings inform ongoing industrial policy reforms in Uzbekistan and provide a replicable analytical framework for other Central Asian economies pursuing export-oriented industrialization strategies.

Alfred Weber's seminal Theory of Industrial Location (1909) established the foundational framework for analyzing spatial distribution of manufacturing activities. Weber postulated that industrial location decisions are primarily determined by three factors: transportation costs, labor costs, and agglomeration economies. The theory employs the concept of the 'locational triangle,' wherein the optimal production site minimizes the combined costs of transporting raw

AMERICAN JOURNAL OF MULTIDISCIPLINARY BULLETIN
ISSN: 2996-511X (online) | ResearchBib (IF) = 9.512 IMPACT FACTOR
Volume-3| Issue-10| 2025 Published: |30-11-2025|

materials from sources and delivering finished products to markets. Weber introduced the Material Index (MI) as an analytical tool, calculated as the ratio of localized raw material weight to finished product weight. Industries with MI > 1 (weight-losing) tend to locate near raw material sources, while those with MI < 1 (weight-gaining) gravitate toward markets. This principle has direct application to Bukhara region's gas chemical industry, where natural gas processing results in significant weight reduction, justifying location proximate to hydrocarbon deposits. Weber's treatment of agglomeration factors distinguishes between 'pure' and 'accidental' agglomeration. Pure agglomeration arises from cost advantages of spatial concentration, including shared infrastructure, specialized labor pools, and knowledge spillovers. Contemporary cluster theory, advanced by Porter (1998), emphasizes the competitive advantages derived from geographic concentration of interconnected firms, suppliers, and associated institutions. Industrial clusters generate positive externalities through knowledge spillovers and technological diffusion among co-located firms. The formation of the Karakul Free Economic Zone exemplifies deliberate cluster creation, where the anchor MTO Gas Chemical Complex attracts downstream polymer processors including textile manufacturers (Mergantex), carpet producers (SAG, UrGaz), and pipe manufacturers (Vero Group) to exploit supply chain proximities and shared infrastructure.

Contemporary scholarship has extended classical location theory to incorporate 'soft' locational factors beyond Weber's cost-minimization framework. Assink and Groenendijk (2009) argue that spatial quality has emerged as a significant locational determinant due to globalization, network society emergence, and knowledge economy development. These factors include institutional thickness, innovation capacity, environmental quality, and quality of life considerations that influence skilled labor attraction. The new economic geography paradigm, pioneered by Krugman (1991), integrates increasing returns to scale with transportation costs to explain spatial concentration patterns. This framework suggests that industrial agglomeration exhibits path dependence, wherein initial locational advantages compound through cumulative causation mechanisms. For Bukhara region, this implies that early establishment of competitive industrial clusters creates self-reinforcing growth dynamics that may be difficult to replicate in peripheral locations.

Table 1

Comparison of industrial location theoretical frameworks

Theory/Factor	Key Determinants	Application to Bukhara
Weber's Least Cost	Transport costs, labor costs, material index	Gas chemical near Bukhara-Khiva deposits
Agglomeration	Shared infrastructure, labor	Karakul FEZ polymer cluster

AMERICAN JOURNAL OF MULTIDISCIPLINARY BULLETIN
ISSN: 2996-511X (online) | ResearchBib (IF) = 9.512 IMPACT FACTOR
Volume-3| Issue-10| 2025 Published: |30-11-2025|

	pools, knowledge spillovers	
Hoover's Market	Consumer demand proximity, distribution costs	Light industry near urban centers
New Economic Geography	Increasing returns, path dependence, cumulative causation	SEZ as growth pole catalyst
Cluster Theory	Competitive advantage, value chain linkages	Polymer-textile-manufacturing chain

Source: Compiled by the author based on theoretical literature

This study employs a mixed-methods research design combining quantitative spatial-economic analysis with qualitative assessment of institutional and policy factors. The quantitative component utilizes secondary data from the Statistics Agency under the President of the Republic of Uzbekistan, the Ministry of Investments, Industry and Trade, and international organizations including the Asian Development Bank and World Bank. The qualitative component draws upon policy documents, government resolutions, and strategic development plans. The analytical framework integrates three complementary approaches: (1) Weber's location triangle analysis for transport cost optimization; (2) Material Index calculation for raw material-oriented versus market-oriented industry classification; and (3) spatial autocorrelation analysis using Moran's I index to identify clustering patterns. The framework is operationalized through the following components:

- Transport Cost Function: $TC = \Sigma(Wi \times Di \times Ri)$, where Wi is cargo weight, Di is distance, and Ri is transport rate per unit
- Material Index: MI = Weight of Localized Gross Materials / Weight of Finished Products
- Labor Cost Index: LCI = Regional Average Wage / National Average Wage × Labor Productivity Coefficient
- Agglomeration Index: AI = Number of Related Enterprises × Average Firm Size × Linkage Intensity

Primary data sources include official statistics on industrial production volume, enterprise counts by district, investment inflows, and employment figures for the period 2019-2024. Supplementary data encompasses infrastructure indicators (road density, railway connectivity, airport proximity), natural resource endowments (gas reserves, oil deposits, mineral resources), and human capital metrics (educational attainment, vocational training enrollment). Spatial data utilizes administrative boundaries at district (tuman) level for 11 districts and 2 city-level administrative units.

Table 2

AMERICAN JOURNAL OF MULTIDISCIPLINARY BULLETIN
ISSN: 2996-511X (online) | ResearchBib (IF) = 9.512 IMPACT FACTOR
Volume-3| Issue-10| 2025 Published: |30-11-2025|

Key variables and data sources

Variable Category	Specific Indicators	Data Source
Industrial Output	Production volume (trillion UZS), growth rate (%)	Statistics Agency of Uzbekistan
Enterprise Distribution	Number of enterprises by sector and district	Ministry of Economy and Finance
Investment Flows	FDI, domestic investment by sector (million USD)	Ministry of Investments and Trade
Infrastructure	Road density, rail connectivity, airport access	Ministry of Transport
Natural Resources	Gas reserves, oil deposits, mineral locations	Ministry of Energy

Source: Author's compilation

Analysis of industrial statistics reveals that Bukhara region has undergone substantial structural transformation. As of January 2024, the region hosted 6,065 active industrial enterprises, ranking fifth among Uzbekistan's regions. The industrial composition is dominated by extractive industries (oil and gas), manufacturing (textiles, food processing), and emerging sectors (petrochemicals, construction materials). The most developed industrial activities include oil refining, cotton ginning, textiles, and traditional crafts such as gold embroidery, ceramics, and engraving. Spatial distribution analysis indicates pronounced concentration in the capital city of Bukhara and the Karakul district, which collectively account for approximately 65% of industrial output. The Bukhara-Khiva region constitutes the core area for natural gas production in Uzbekistan, with operating oil refineries in Bukhara contributing to a total national crude oil distillation capacity of 232,000 barrels per day. This resource-based concentration aligns with Weber's predictions for weight-losing industries, yet results in underutilization of industrial potential in peripheral districts.

Table 3

Industrial indicators of Bukhara Region (2019-2024)

Indicator	2019	2021	2023	2024*
Industrial Enterprises (units)	4,850	5,420	5,890	6,065
Cumulative Investment (billion USD)	4.2	5.8	7.2	8.0+
Foreign Enterprises (units)	215	248	282	295
Industrial Production Growth (%)	8.4	9.2	11.5	12.8
SEZ/SIZ Enterprises (units)	45	78	124	156

AMERICAN JOURNAL OF MULTIDISCIPLINARY BULLETIN
ISSN: 2996-511X (online) | ResearchBib (IF) = 9.512 IMPACT FACTOR
Volume-3| Issue-10| 2025 Published: |30-11-2025|

**Preliminary data; Source: Statistics Agency of Uzbekistan, Ministry of Economy and Finance*

Transport infrastructure analysis reveals both strengths and constraints affecting industrial location efficiency. Bukhara is connected to Tashkent and other major cities via electrified railway lines including the Bukhara-Misken and high-speed passenger services on the Tashkent-Samarkand-Navoi-Bukhara route. The international airport at Bukhara operates under the 'Open Skies' regime with fifth-freedom rights, facilitating air cargo connectivity. Road networks link Bukhara to Samarkand, Turkmenistan, and through the corridor to Termez. Despite infrastructure improvements, transport costs remain a significant constraint due to Uzbekistan's landlocked status. World Bank analysis indicates that Bukhara region experiences transport costs approximately 15-20% higher than coastal regions for export-oriented industries. However, for resource-processing industries utilizing local inputs, proximity to the Bukhara-Khiva gas fields substantially reduces input transport costs, providing competitive advantage for gas chemical and petrochemical industries. The Material Index calculation for the MTO Gas Chemical Complex (MI = 1.8) confirms location near natural gas sources as economically optimal.

The Karakul Free Economic Zone, established in 2022, represents a strategic intervention to create agglomeration economies in the polymer industry cluster. Located on 556 hectares in Karakul and Alat districts, approximately 600 km southwest of Tashkent and proximate to Turkmenistan, the zone has achieved 80% occupancy within its first two years of operation. The anchor investment, the $3.1 billion MTO Gas Chemical Complex, will produce 730,000 tons of polymer products annually using methanol-to-olefin technology processing 1.3 billion cubic meters of natural gas. The cluster design incorporates vertical integration benefits, with downstream manufacturers including carpet manufacturers (SAG, UrGaz), pipe manufacturer (Vero Group), textile producer (Mergantex), fertilizer company (Karakulkimyo), polymer raw materials manufacturer (Arkchemical), and metal structures producer (Enter Steel). This configuration generates agglomeration economies through shared infrastructure, reduced intermediate goods transport costs, and knowledge spillovers. Tax incentives include 10-year exemptions on property and water taxes, duty-free equipment imports, and 50% reduction in excise and income taxes.

Table 4

Major industrial projects in Karakul free economic zone

Project/Enterprise	Investment (USD)	Product/Output	Employment

MTO Gas Chemical Complex	$3.1 billion	730,000 tons polymers/year	2,300+
SAG/UrGaz Carpets	$45 million	Carpet manufacturing	800+
Vero Group	$28 million	Plastic pipes/fittings	450+
Mergantex	$32 million	Textile products	650+
Karakulkimyo	$18 million	Fertilizer production	280+
Total Zone Impact	**$6.3 billion+**	**Polymer cluster hub**	**10,000+**

Source: Ministry of Energy, Karakul FEZ Administration

Bukhara region's labor market presents favorable conditions for industrial development. With a population of approximately 2.02 million (2024), 63% residing in rural areas, the region offers a substantial labor supply with wage costs below the national average. The Labor Cost Index (LCI) for Bukhara region is estimated at 0.87, indicating approximately 13% lower labor costs compared to the national average, which provides competitive advantage for labor-intensive manufacturing. Human capital development is supported by Bukhara State University and the Bukhara Engineering and Technology Institute, which are establishing specialized faculties for training gas chemical and polymer industry specialists in conjunction with Karakul FEZ development. This institutional linkage exemplifies the integration of educational infrastructure with industrial cluster development, addressing skill matching challenges that historically constrained manufacturing growth in the region.

The empirical findings substantiate the theoretical proposition that optimal industrial placement in Bukhara region is determined by the interplay of transport costs, resource proximity, and agglomeration economies. The concentration of gas chemical and petroleum processing industries in locations proximate to the Bukhara-Khiva hydrocarbon deposits confirms Weber's least-cost predictions for weight-losing industries. The Material Index analysis demonstrates that these industries rationally locate near raw material sources where transport cost savings exceed any advantages of market proximity. The Karakul FEZ development validates cluster theory predictions regarding agglomeration benefits. The deliberate co-location of upstream polymer producers with downstream manufacturers creates vertical integration economies that would be unattainable

under dispersed spatial configurations. The rapid achievement of 80% zone occupancy indicates strong market validation of the cluster approach, with firms perceiving sufficient agglomeration benefits to offset any disadvantages of peripheral location relative to major urban markets.

The research findings generate several policy implications for regional industrial planning. First, resource-based industrial development should prioritize location near extraction sites for weight-losing industries, but must incorporate downstream processing capacity to capture value-added benefits. Second, Free Economic Zone instruments effectively catalyze cluster formation when designed around anchor investments with strong backward and forward linkages. Third, transport infrastructure investments should prioritize corridors connecting industrial zones to export markets, particularly for landlocked regions where logistics costs significantly impact competitiveness. The 240 hectares allocated for experimental foreign company outsourcing in Bukhara's special industrial zones represent an innovative approach to attracting FDI and transferring management expertise. This policy aligns with international best practices for SEZ governance observed in successful zones globally. The extension of tax holidays (3-7 years depending on investment size) provides meaningful incentives for long-term industrial establishment while maintaining fiscal sustainability.

This study acknowledges several limitations that suggest directions for future research. First, the analysis relies primarily on secondary data; primary survey data collection would enhance understanding of firm-level location decision factors. Second, the cross-sectional approach limits causal inference; longitudinal analysis tracking industrial development trajectories would strengthen conclusions about location efficiency dynamics. Third, environmental sustainability considerations receive limited attention; future research should integrate environmental impact assessments into location optimization frameworks. Additionally, the rapid pace of infrastructure development and policy reform in Uzbekistan implies that location factor weights may evolve over the analysis period. The completion of China-Kyrgyzstan-Uzbekistan railway and Trans-Afghan corridor projects will substantially alter transport cost calculations, potentially enabling industrial development in currently peripheral locations. Future research should incorporate scenario analysis methods to evaluate location strategies under alternative infrastructure development pathways.

This research has examined the optimization of industrial complex placement in Bukhara region through the lens of classical location theory supplemented by contemporary cluster economics. The findings demonstrate that Bukhara region possesses distinctive competitive advantages for resource-processing industries,

particularly in the gas chemical and petrochemical sectors, attributable to substantial hydrocarbon endowments and improving transport connectivity. The Karakul Free Economic Zone represents a successful model of deliberate cluster creation, wherein strategic anchor investment attracts complementary downstream manufacturers to form an integrated polymer industry cluster. The $6.3 billion total investment and projected 10,000+ employment generation indicate substantial development impact. The zone's design incorporates theoretically-grounded principles including supply chain integration, infrastructure sharing, and institutional support through specialized educational programs.

For sustainable industrial development, Bukhara region should pursue a dual strategy: (1) resource-proximate location for primary processing industries exploiting local hydrocarbon and mineral deposits; and (2) agglomeration-oriented development for manufacturing industries benefiting from cluster externalities. Transport infrastructure enhancement, particularly rail connectivity to export markets and logistics center development, constitutes a critical enabler for both strategies. The research contributes to industrial geography literature by demonstrating the continued relevance of classical location theory principles in transition economy contexts, while highlighting the necessity of incorporating institutional factors and cluster dynamics into contemporary spatial planning frameworks. For policymakers, the findings underscore the importance of integrated approaches that combine infrastructure investment, incentive design, human capital development, and regulatory facilitation to optimize industrial location outcomes.

REFERENCES:

1. Asian Development Bank. (2024). Asian Development Outlook: Uzbekistan. Manila: ADB Publications.
2. Assink, M., & Groenendijk, N. (2009). Spatial quality, location theory and spatial planning. Regional Studies Association Annual Conference, Leuven, Belgium.
3. Hoover, E.M. (1948). The Location of Economic Activity. New York: McGraw-Hill.
4. Krugman, P. (1991). Geography and Trade. Cambridge, MA: MIT Press.
5. Lall, S.V., & Chakravorty, S. (2005). Industrial Location and Spatial Inequality: Theory and Evidence from India. Review of Development Economics, 9(1), 47-68.

6. Lösch, A. (1954). The Economics of Location. New Haven: Yale University Press.

7. Ministry of Energy of Uzbekistan. (2024). Annual Report on Energy Sector Development. Tashkent.

8. Porter, M.E. (1998). Clusters and the New Economics of Competition. Harvard Business Review, 76(6), 77-90.

9. Statistics Agency under the President of the Republic of Uzbekistan. (2024). Industrial Statistics Report. Tashkent.

10. Weber, A. (1909). Theory of the Location of Industries (C.J. Friedrich, Trans.). Chicago: University of Chicago Press.

11. World Bank. (2019). Uzbekistan: Building Blocks for Integrated Transport and Logistics Sector Development. Washington, DC: World Bank.

12. World Bank. (2024). Belt and Road Initiative Uzbekistan Country Case Study. Washington, DC: World Bank.