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A Study on the Evaluation of Uzbekistan's Logistics Competitiveness under the Belt and Road Initiative

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Abstract: The Belt and Road Initiative (BRI) is a key driver of global economic cooperation, fostering regional connectivity and development. Uzbekistan, a central hub in Central Asia, plays a vital role in the BRI due to its strategic location. Enhancing its logistics competitiveness is critical for both its economic growth and regional trade. This study combines factor analysis and literature review to assess Uzbekistan's logistics competitiveness, evaluating infrastructure, economic scale, market performance, informatization, and human resources. Findings reveal strengths in infrastructure and economic scale but weaknesses in informatization and workforce quality. To address these gaps, the paper proposes strategies such as boosting trade, upgrading infrastructure, advancing digitalization, nurturing talent, and improving policies. Under the BRI, Uzbekistan's logistics sector holds significant potential for growth.

Keywords: Belt and Road Initiative; Uzbekistan; Logistics competitiveness; Improvement strategies.

1. Introduction

1.1. Research Background

Uzbekistan, a Central Asian country with rich history, is a key participant in China's Belt and Road Initiative (BRI). The BRI aims to promote economic cooperation and shared development. Uzbekistan's participation addresses employment issues and enhances logistics development. As a double landlocked country with over 32 million people, Uzbekistan lacks modern logistics infrastructure despite its historical trade role. The government's $55 billion five-year plan focuses on industrial modernization and infrastructure. BRI cooperation helps Uzbekistan regain Silk Road prominence. Currently, Uzbekistan's logistics sector remains underdeveloped. BRI participation is crucial for improving its international logistics competitiveness. This research analyzes Uzbekistan's macro-environment, evaluates logistics competitiveness, and proposes strategic recommendations.

1.2. Research Significance

1.2.1. Theoretical Significance

Existing BRI research focuses on macro-strategy with limited sectoral analysis. This study builds a logistics competitiveness index system covering economy, infrastructure, technology and policy. It provides a framework for analyzing BRI countries' logistics competitiveness, enriching theoretical research.

1.2.2. Practical Significance

Uzbekistan views logistics development as vital for economic modernization. This study identifies industry weaknesses and improvement paths, supporting policy-making. It also offers insights for other landlocked BRI nations seeking mutual development.

1.3. Research Content and Methodology

1.3.1. Research Content

The research focuses on Uzbekistan's BRI logistics competitiveness. It examines the development status, constructs an evaluation system with 5 primary and 20 secondary indicators, conducts empirical analysis using factor analysis, evaluates competitiveness compared to regional peers, proposes improvement measures, and concludes with future research directions.

1.3.2. Methodology

The study employs both qualitative methods including literature review and SWOT analysis, and quantitative methods featuring factor analysis and comparative evaluation of logistics competitiveness indicators.

1.3.3. Research Methods

(1) Literature Review Method

This systematic approach involves collecting and analyzing relevant literature to summarize research status, trends, and gaps. Applied to Uzbekistan's BRI logistics competitiveness, it clarifies the research scope, establishes theoretical frameworks, and identifies innovation opportunities through comprehensive paper reviews.

(2) Factor Analysis Method

This statistical method reduces data dimensionality and reveals variable relationships. The study applies it to Uzbekistan's logistics competitiveness by constructing a multidimensional evaluation system (economic environment, infrastructure, informatization, etc.), collecting data, and extracting key factors. The results identify strengths/weaknesses and support strategy formulation.

2. Theoretical Foundations and Literature Review

2.1. Theoretical Foundations

2.1.1. Concept of Logistics

Logistics is a crucial component of modern supply chain management, covering the process from raw material procurement to final product distribution. Its core goal is to optimize resource allocation and process management, ensuring efficiency while meeting customer demands. Logistics management is a systemic process involving multiple stages and participants, allowing for flexible strategy adjustments in dynamic market conditions.

Key logistics characteristics include systematicity,

dynamism, coordination, and informatization. Logistics is highly systematic, with interconnected stages requiring coordinated management. It is also dynamic, as fluctuating demands and resources necessitate real-time adjustments. Coordination among suppliers, manufacturers, distributors, and consumers enhances efficiency, while informatization ensures real-time tracking and decision-making through systems like Logistics Management Systems (LMS) and Enterprise Resource Planning (ERP).

2.1.2. Concept of Logistics Competitiveness

Logistics competitiveness combines internal capabilities and external conditions that provide an organization with logistical advantages. Internally, it includes the efficiency of logistics facilities, dynamic management capabilities, and overall operational control, enabling cost reduction and service quality improvement. Externally, factors like government policies and geographical location influence competitiveness by enhancing intrinsic strengths.

Logistics competitiveness is linked to corporate and industrial competitiveness. Corporate logistics competitiveness reflects a company's ability to gain market advantage through efficient logistics, while industrial competitiveness refers to a region's ability to provide superior logistics services. It is assessed through market strength indicators (market share, ROI), technical strength indicators (R&D investment, technical personnel ratio), and organizational coordination indicators (information flow, cohesion).

2.2. Literature Review

2.2.1. Research on Logistics Competitiveness

Research on logistics competitiveness has developed based on Porter's "Four-Factor Model." Early studies focused on logistics planning, while recent research emphasizes technological applications and system sustainability.

Dong Yao (2022) examined QM E-Commerce Ltd.'s logistics competitiveness under e-commerce demands, using SWOT analysis to suggest improvements in service quality and cost control. Wang Chunying et al. (2023) proposed a regional logistics competitiveness evaluation model using the CRITIC-entropy weight and Mahalanobis distance TOPSIS methods. Their study found decreasing logistics competitiveness from coastal to inland China. Wang Yiliang (2023) analyzed port logistics under free trade zones, suggesting standardization and informatization to enhance services. Ma Weihua et al. (2023) extended the research to urban logistics, evaluating cities in the Yangtze River Delta. Wang Zhiling (2024) assessed logistics competitiveness along the Western Land-Sea New Corridor, identifying disparities between provinces. Jia Xianmin et al. (2024) examined trade logistics evolution across the same corridor, highlighting digitalization gaps as a major challenge.

2.2.2. Research on Logistics Competitiveness Evaluation Methods

Li Ming (2021) used factor analysis to assess commercial logistics competitiveness in nine core cities of Guangdong, revealing varying development levels. Wu Yunxuan (2022) applied the DEA-Malmquist model and spatial econometric analysis to study trade competitiveness in 21 logistics hub cities, noting strong performance in eastern China but weaker development in central and western regions. Shi Xuegang et al. (2023) evaluated logistics competitiveness in the Middle Yangtze River urban agglomeration, categorizing 31 cities into four tiers. Yang Xinrui et al. (2024) used entropy weight-TOPSIS to analyze logistics competitiveness in the Pearl River Delta, identifying competitive clusters.

Hou Mingyu (2024) studied the Beijing-Tianjin-Hebei logistics cluster using entropy weight and coupling coordination models, noting competitiveness disparities among cities. The study suggested infrastructure, informatization, talent development, and policy support as key improvement areas. Chen Jiayuan et al. (2024) applied principal component analysis to Guangdong's logistics competitiveness, identifying Guangzhou, Shenzhen, Dongguan, and Foshan as core hubs. The study proposed a "dual-pole" logistics network to balance development.

2.2.3. Research on Logistics Competitiveness Evaluation Indicators

Scholars have developed various evaluation systems for logistics competitiveness. Xu Xin (2010) outlined four key factors shaping enterprise competitiveness: business environment, resources, capabilities, and knowledge. Wang Jian et al. (2014) refined this into a 24-indicator system covering economic efficiency, financial status, management, and technology.

Guo Zixue et al. (2017) created an evaluation model for Hebei's logistics industry, assessing market competitiveness, technological innovation, and service quality. Yue Qi (2019) developed a 32-indicator system for regional logistics competitiveness using grey correlation and principal component analysis, evaluating China's 31 provinces. Li Nan (2022) introduced a three-tier model categorizing urban logistics competitiveness into strength, potential, and environment, applying deep learning techniques for feature analysis.

Despite extensive research, studies on Uzbekistan's logistics competitiveness remain limited. This study aims to fill that gap, offering insights to strengthen Uzbekistan's position in the "Belt and Road" initiative.

2.2.4. Research on China-Uzbekistan Logistics

Most existing studies focus on the logistics industry within a single country, while comparative research on China and Uzbekistan's logistics industries is rare. Trade between the two countries forms the foundation of logistics cooperation, with research primarily examining economic and trade relations.

Liu Yang (2022) analyzed China-Uzbekistan agricultural trade under the Shanghai Cooperation Organization (SCO) and the Belt and Road Initiative (BRI). The study highlights Uzbekistan's role as a major fruit and vegetable producer in Central Asia and explores trade potential, emphasizing deeper cooperation. Deng Yujia et al. (2023) used a trade gravity model to assess China-Uzbekistan agricultural trade, identifying challenges such as weak economic resilience, low logistics performance, and rising trade barriers. The authors suggest strengthening cotton industry collaboration, innovating trade models, and improving trade facilitation.

Tao Xinping et al. (2024) examined agricultural trade between Xinjiang and Uzbekistan, proposing policy recommendations for high-quality trade development. Luo Qi et al. (2024) studied China-Uzbekistan cotton trade, revealing Uzbekistan's stronger competitiveness in cotton exports and recommending increased Chinese investment.

A 2016–2020 report by Zhengdian International and the Ministry of Commerce analyzed Uzbekistan's logistics sector, highlighting investment risks and opportunities under the BRI. Gafforov Rakhim (2022) explored China-Uzbekistan transport and logistics cooperation, addressing factors such as

infrastructure needs, political concerns, and economic reliance on China.

Internationally, China-Uzbekistan cooperation remains under-researched. Scholars like Behera and

2.2.5. Literature Review

Research on logistics competitiveness has evolved from early planning studies to refined evaluation models. Porter's Four-Factor Model remains a key framework, further developed through methods like factor analysis, SWOT analysis, entropy weight methods, and fuzzy evaluation. Studies assess logistics competitiveness through both direct indicators (scale, demand) and indirect factors (infrastructure, innovation).

For China-Uzbekistan logistics, research mainly examines bilateral trade, particularly in agriculture. Some studies assess transport and logistics cooperation under the BRI, recognizing its potential benefits. However, gaps remain:

• Few studies focus on Uzbekistan's logistics competitiveness, with most research centered on developed regions.

• Comparative studies on China-Uzbekistan logistics are scarce, lacking a comprehensive analysis of industry strengths, weaknesses, and cooperation potential.

• Data limitations and analytical challenges hinder policy implementation, making it difficult to translate research into actionable measures.

3. Research on Uzbekistan's Logistics Industry

3.1. The Belt and Road Initiative

The Belt and Road Initiative (BRI), launched by China in 2013, is a global development strategy inspired by the ancient Silk Road. It aims to enhance economic cooperation and connectivity between participating countries. The BRI consists of two main components:

• Silk Road Economic Belt: A land-based network linking East Asia to Europe via Central Asia.

• 21st Century Maritime Silk Road: A sea route connecting Asia, Europe, and Africa.

As of 2018, 65 countries had joined the BRI, spanning East Asia, Central and Eastern Europe, South Asia, West Asia, North Africa, and Russia.

3.2. Development of Uzbekistan's Logistics Industry

3.2.1. Economic Overview

Uzbekistan, located in Central Asia, borders Kazakhstan, Afghanistan, Turkmenistan, Kyrgyzstan, and Tajikistan. It is the region's most populous country, with over 35 million people as of 2023. Covering 448,978 square kilometers, Uzbekistan has historically been a key trade hub along the Silk Road.

The country operates as a presidential republic and has implemented significant economic reforms in recent years, focusing on diversification beyond energy exports. Uzbekistan is rich in natural gas, petroleum, gold, and cotton, with ongoing efforts to expand manufacturing, services, and tourism.

From 2010 to 2023, Uzbekistan's GDP rose from $39.5 billion to $90.8 billion, with a notable 12.9% growth in 2023. The BRI has played a crucial role in infrastructure improvements, boosting logistics and overall economic competitiveness.

3.2.2. Resource Availability

Uzbekistan's economic strength is supported by abundant natural resources:

• Energy Resources: A major natural gas producer, Uzbekistan exports significant amounts of gas and also holds petroleum and coal reserves.

• Mineral Resources: The country is a top ten global gold producer, with large reserves of copper and uranium.

• Agricultural Resources: Uzbekistan is one of the world's largest cotton producers, with agriculture also supporting wheat, rice, vegetables, and fruit production.

• Water Resources: Despite being landlocked, Uzbekistan relies on the Amu Darya and Syr Darya rivers for irrigation, with recent efforts focused on sustainable water management.

A summary table outlines Uzbekistan's major resource production trends over the past decade, including natural gas, petroleum, gold, and cotton.

Table 3-1. Resource Status of Uzbekistan (2013–2023)

Year	Natural Gas Production (Billion Cubic Meters)	Oil Production (Million Tons)	Gold Production (Tons)	Cotton Production (Million Tons)
2013	60	3.2	90	3.5
2014	59	3.1	88	3.6
2015	58	3	87	3.7
2016	57	2.9	85	3.8
2017	56	2.8	84	3.6
2018	55	2.7	83	3.4
2019	54	2.6	82	3.3
2020	53	2.5	80	3.2
2021	52	2.4	78	3.4
2022	51	2.3	77	3.5
2023	50	2.2	75	3.6

3.2.3. Uzbekistan's Infrastructure Status

Uzbekistan's logistics infrastructure plays a key role in economic growth, bolstered by investments under the Belt and Road Initiative (BRI). Railway freight rose from 105 million tons in 2019 to 120 million tons in 2023, while road freight increased from 410 million to 450 million tons. Air freight grew from 100,000 to 125,000 tons, reflecting the demand for high-value cargo transport. Waterway freight remained stable, underscoring its limited role in an inland country. Overall, Uzbekistan's transport capacity has expanded, strengthening economic development.

(1) Railway Transport

Uzbekistan's 7,000 km railway network is Central Asia's most developed, handling over 60% of national freight and linking major cities with Kazakhstan, Turkmenistan, and Tajikistan. Routes such as Tashkent-Andijan and Tashkent-Bukhara integrate with China's and Russia's rail networks, facilitating trade. Under BRI, key upgrades include the Angren-Pap railway tunnel (19 km), reducing travel time between Fergana Valley and central Uzbekistan. By 2022, railway freight reached 120 million tons, a 4.5% annual increase.

(2) Road Transport

With 43,000 km of roads (85% paved), Uzbekistan's highways connect major cities and neighboring countries.

Key routes include M34 (Tashkent-Samarkand) and A373 (Tashkent-Osh, Kyrgyzstan). The 2021-2025 Transport Development Plan allocates $12 billion for road improvements, boosting efficiency. By 2023, road freight reached 450 million tons, 35% of total freight.

(3) Air Transport

Uzbekistan's aviation sector is expanding, with Islam Karimov Tashkent International Airport handling 5 million passengers and 60,000 tons of cargo annually. Other key airports include Bukhara, Samarkand, and Fergana, with frequent international flights. A new cargo terminal at Tashkent Airport will add 100,000 tons of capacity per year. By 2022, air freight reached 120,000 tons (8.5% growth).

(4) Waterway Transport

As a landlocked country, Uzbekistan relies on Amu Darya and Syr Darya rivers for limited transport, mainly agricultural products and construction materials. While BRI has opened opportunities for regional trade, waterway transport remains under 1% of total freight (3 million tons in 2023).

3.3. Opportunities and Challenges in Uzbekistan's Logistics Industry

3.3.1. Opportunities for Uzbekistan's Logistics Development

(1) Accelerated Infrastructure Development – BRI provides funding and technical support for transport projects, including the Tashkent-Andijan railway tunnel and CAREC-funded regional infrastructure.

(2) Stronger International Cooperation – Partnerships with China, Russia, and Kazakhstan drive logistics modernization and smart logistics adoption, enhancing Uzbekistan's role as a regional hub.

(3) Market Expansion Potential – Improved logistics networks facilitate exports of cotton, fruits, minerals, and industrial goods to China, Europe, and the Middle East.

(4) Policy Optimization – Pro-business reforms attract foreign investment in logistics infrastructure and foster regional trade agreements.

3.3.2. Challenges in Uzbekistan's Logistics Industry

(1) Infrastructure Gaps – Despite progress, unhardened roads and limited waterways reduce logistics efficiency, while landlocked geography limits sea trade.

(2) Low Digitalization – Many logistics firms lack advanced management systems, data-sharing platforms, and e-commerce integration, leading to inefficiencies.

(3) Intensified Market Competition – Global logistics firms entering Uzbekistan challenge local companies that struggle with technology, funding, and management experience.

(4) Policy Implementation Issues – Inconsistent enforcement of government policies slows infrastructure projects, while bureaucratic hurdles limit reforms' effectiveness.

3.4. Problems in Uzbekistan's Logistics

3.4.1. Economic Constraints on Logistics Competitiveness

(1) Insufficient Investment & Infrastructure Modernization – Limited funding results in outdated facilities, reducing logistics efficiency. Poor warehousing, sorting, and transport management hinder international competitiveness.

(2) Monolithic Economy & External Risk Exposure – Dependence on agriculture and mineral exports makes logistics vulnerable to market fluctuations, limiting industry flexibility.

(3) Low Foreign Investment & Internationalization – Weak FDI restricts technology transfer and management improvements, making it difficult for Uzbekistan to integrate into global logistics networks.

3.4.2. Small Logistics Market & Low Competition

(1) Few Logistics Companies & Weak Market Dynamics – A small number of logistics firms, mostly small-scale, leads to low competition, reducing service quality and innovation.

(2) Limited Market Size & Expansion Challenges – The industry's small scale prevents cost reductions, specialization, and efficiency improvements.

(3) Low Service Levels & Customer Satisfaction – Underdeveloped transport networks and poor management reduce timeliness and quality, limiting customer loyalty.

3.4.3. Weak Transport Infrastructure & Low Efficiency

(1) Underdeveloped Network & Regional Bottlenecks – Despite a large railway and road network, cross-regional logistics remain inefficient.

(2) Lack of Warehousing & Logistics Parks – Uneven distribution of storage facilities raises costs and delays operations.

(3) Outdated Transport Technology – Aging railway and road fleets, along with weak digitalization, hinder cost control and competitiveness.

3.4.4. Weak Digitalization & Talent Shortage

(1) Low Adoption of Smart Logistics – Limited use of tracking systems, e-commerce, and big data lowers efficiency.

(2) Shortage of Skilled Workforce – A lack of trained professionals restricts business growth and innovation.

(3) Incomplete Education & Training System – Few specialized programs limit talent development, reducing global competitiveness.

4. Evaluating Uzbekistan's Logistics Competitiveness

4.1. Key Factors in Logistics Competitiveness

After establishing evaluation principles, selecting relevant indicators is essential. This study references literature on regional logistics and identifies five key factors shaping Uzbekistan's logistics development.

(1) Economic Environment – A stable economy supports logistics infrastructure and market demand, enhancing overall industry growth. Key indicators include GDP growth, investment climate, and industrial activity.

(2) Logistics Market – Market openness, competition, and regulation influence logistics efficiency. Uzbekistan's expanding market, driven by policies and foreign investment, is a crucial factor.

(3) Infrastructure – Transportation networks, storage facilities, and IT integration determine logistics capacity. Uzbekistan has improved its infrastructure, especially under the Belt and Road Initiative.

(4) Information Technology – IT advancements boost efficiency through supply chain tracking and route optimization. Key indicators include logistics information systems, e-commerce platforms, and big data applications.

(5) Talent – Skilled professionals enhance logistics operations. Uzbekistan is developing a trained workforce through education and training programs, improving industry competitiveness.

4.2. Evaluation Principles

To ensure accuracy and applicability, logistics competitiveness evaluation follows these principles:

(1) Holistic Approach – Logistics involves interconnected factors such as infrastructure, policy, and international cooperation. Evaluation must consider their combined impact.

(2) Operability – Indicators should reflect Uzbekistan's inland logistics challenges and be practical for policy implementation.

(3) Adaptability – Criteria must align with Uzbekistan's logistics realities, emphasizing rail, road, and air transport.

(4) Simplicity – The evaluation should focus on key indicators like freight volume growth and transport coverage, avoiding excessive complexity.

(5) Objectivity – Data-driven assessment ensures accuracy, relying on quantitative metrics like transport volume and network density.

(6) Scientific Rigor – Indicators must be logically structured, considering Uzbekistan's geography, economy, and international role to support policy development.

Based on a comprehensive assessment and considering the actual logistics situation in Uzbekistan, this study has preliminarily established a logistics competitiveness evaluation index system for Uzbekistan. The system consists of four primary indicators—economic competitiveness, market performance, infrastructure competitiveness, and informatization & logistics talent competitiveness along with 30 secondary indicators, as detailed in the table.

Table 3-2. Preliminary Construction of Uzbekistan's Logistics Competitiveness Evaluation Index System

Primary Indicators	Secondary Indicators
Economic Competitiveness	Total GDP
	Per Capita GDP
	Foreign Direct Investment Amount
	Total Trade Volume
	Inflation Rate
	Unemployment Rate
Market Performance	Number of Logistics Enterprises
	Logistics Market Size
	Import and Export Freight Volume
	Domestic Freight Volume
	Logistics Market Share Growth Rate
	Customer Satisfaction Index
Infrastructure Competitiveness	Infrastructure Competitiveness
	Total Expressway Mileage
	Total Aviation Mileage
	Number of Logistics Parks and Warehousing Facilities
	Total Investment in Transportation
	Port Facility Completeness
	Stability of Energy Supply
Information Technology and Logistics Talent	Information Technology and Logistics Talent Coverage of Logistics Information Platforms
	E-commerce Transaction Volume
	Investment in Logistics Information Infrastructure
	Internet Penetration Rate
	Level of Logistics Big Data Application
	Security of Logistics Information Systems
	Number of Logistics Practitioners
	Number of Logistics Professional Education Institutions
	Coverage of Logistics Personnel Training and Certification
	Logistics Talent Turnover Rate
	Professional Skill Level of Logistics Personnel

Based on the construction principles, the following key evaluation indicators are selected:

Economic Competitiveness

Economic competitiveness reflects Uzbekistan's logistics potential. GDP and GDP per capita indicate economic scale and living standards, supporting logistics demand. FDI and trade volume measure openness and trade activity, driving logistics growth. Inflation and unemployment rates affect costs and market stability.

Market Performance

Market performance assesses logistics industry growth and competitiveness. Key indicators include the number of logistics companies, market size, import-export freight volume, and domestic freight activity. Market share growth and customer satisfaction gauge industry competitiveness and service quality.

Infrastructure Competitiveness

Infrastructure determines transport capacity and service efficiency. Indicators include railway, expressway, and air route mileage, as well as logistics parks, warehouses, and transportation investment. Port facilities and energy stability ensure smooth logistics operations.

IT & Logistics Talent Competitiveness

IT competitiveness reflects modernization and innovation. Indicators include logistics information platform coverage, e-commerce transaction volume, and investment in digital infrastructure. Big data application and cybersecurity assess logistics data management. Talent competitiveness measures workforce quality, including the number of logistics practitioners, education institutions, training programs, and professional skill levels. Talent turnover rates indicate workforce stability.

4.3. Optimization of the Evaluation Indicator System

4.3.1. Data Collection and Organization

Table 4-1. Descriptive Statistics of Evaluation Indicators

Indicator	Average Value
Total GDP	4.84
Per capita GDP	4.81
Foreign direct investment	4.63
Total trade volume	4.72
Inflation rate	4.73
Number of logistics companies	4.88
Logistics market size	4.77
Import and export freight volume	4.75
Domestic freight volume	4.67
Customer satisfaction index	4.31
Total railway mileage	4.82
Total expressway mileage	4.71
Total aviation mileage	4.71
Number of logistics parks and storage facilities	4.69
Total transportation investment	4.67
Completeness of port facilities	4.22
Stability of energy supply	4.27
Coverage of logistics information platforms	4.87
E-commerce transaction volume	4.72
Logistics information infrastructure investment	4.77
Internet penetration rate	4.69
Level of logistics big data application	4.43
Security of logistics information systems	4.44
Number of logistics industry employees	4.78
Number of logistics education institutions	4.85
Coverage of logistics employee training and certification	4.72
Professional skill level of logistics industry employees	4.45

To enhance the evaluation system's validity and practicality, a questionnaire survey was conducted. The survey targeted logistics company employees, customers, and industry experts in Uzbekistan, ensuring diverse representation by including firms of various sizes and types.

A total of 500 questionnaires were distributed, using a five-point Likert scale to assess the importance of each secondary indicator. By the deadline, 380 responses were received (76% response rate), including 190 from logistics employees, 160 from customers, and 30 from experts. After screening for completeness and accuracy, 360 valid responses were used for data analysis and system optimization.

4.3.2. Exploratory Factor Analysis

In the study of logistics competitiveness evaluation, to accurately identify and extract the key factors affecting logistics competitiveness, we employed an exploratory factor analysis method. Through multiple rounds of factor analysis, factors with low loadings were gradually eliminated, aiming to build a more refined and effective evaluation indicator system. Below is the table outlining the process of the exploratory factor analysis.

Table 4-2. Exploratory Factor Analysis

Rotation	KMOValue	Bartlett's Significance Value	Number of Items to Be Tested	Number of Factors Generated	Cumulative Variance	Operation
1	0.902	0.000	27	6	67.367%	Remove the four factors: inflation rate, customer satisfaction, logistics personnel professional skills, and logistics big data application.
2	0.901		23	5	68.255%	Remove the factor of logistics information system security.
3	0.904		22	5	69.762%	Remove the factor of port facility completeness.
4	0.903		21	5	69.753%	Remove the factor of energy supply stability.
5	0.905		20	4	65.858%	The final evaluation indicators obtained

(1) First EFA Round

KMO=0.902 (>0.60); Bartlett's test significant (p=0.000). Initial 27 items reduced to 6 factors (67.367% variance). Excluded 4 factors (inflation rate, customer satisfaction, etc.) due to low loadings.

(2) Second EFA Round

KMO=0.901; Bartlett's test significant. 23 items → 5 factors (68.255% variance). Excluded logistics info system security for low loadings.

(3) Third EFA Round

KMO=0.904; Bartlett's test significant. 22 items → 5 factors (69.762% variance). Excluded port facility adequacy.

(4) Fourth EFA Round

KMO=0.903; Bartlett's test significant. 21 items → 5 factors (69.753% variance). Excluded energy supply stability.

(5) Fifth EFA Round

KMO=0.905 (highest); Bartlett's test significant. 20 items → 4 factors (65.858% variance). Structure stabilized; proceeded to reliability testing.

Outcome: Five EFA rounds refined 20 items into 4 factors, supported by high KMO/variance. The resulting evaluation system for Uzbekistan's logistics covers economic

environment, market, infrastructure, informatization, and talent (20 sub-indicators), enabling targeted competitiveness analysis.

Table 4-3. Uzbekistan Logistics Competitiveness Evaluation System

Target Level	Criteria Level	Indicator Level
Uzbekistan Logistics Competitiveness Evaluation System (C)	Economic Competitiveness (C1)	Total GDP (C11)
		Per Capita GDP (C12)
		Foreign Direct Investment (C13)
		Total Trade Volume (C14)
	Market Performance (C2)	Number of Logistics Enterprises (C21)
		Logistics Market Scale (C22)
		Import and Export Freight Volume (C23)
		Domestic Freight Volume (C24)
	Infrastructure Competitiveness (C3)	Total Railway Mileage (C31)
		Total Highway Mileage (C32)
		Total Aviation Mileage (C33)
		Number of Logistics Parks and Warehousing Facilities (C34)
		Total Transportation Investment (C35)
	Information Technology and Logistics Talent (C4)	Logistics Information Platform Coverage (C41)
		E-commerce Transaction Volume (C42)
		Logistics Information Infrastructure Investment (C43)
		Internet Penetration Rate (C44)
		Number of Logistics Practitioners (C45)
		Number of Logistics Education Institutions (C46)
		Logistics Practitioner Training and Certification Coverage (C47)

Economic Competitiveness (C1):

GDP growth, per capita GDP, FDI, and trade volume reflect Uzbekistan's economic health and its ability to support logistics growth, attracting investment and expanding markets.

Market Performance (C2):

Logistics market size, company count, and freight volumes (import/export, domestic) indicate market maturity and potential, crucial for regional competitiveness under the Belt and Road initiative.

Infrastructure Competitiveness (C3):

Rail/road length, airport capacity, logistics parks, and transport investment show infrastructure completeness, affecting domestic and international logistics efficiency.

Informatization Competitiveness (C4):

Logistics platform coverage, e-commerce volume, IT investment, and internet penetration drive operational efficiency, cost reduction, and service responsiveness.

Human Resources Competitiveness (C5):

Logistics workforce size, education institutions, and training/certification rates measure talent development, essential for innovation and service quality.

5. Logistics Competitiveness Evaluation of Uzbekistan

5.1. Introduction to Factor Analysis Method

Factor Analysis in Logistics Competitiveness Evaluation

Factor analysis simplifies complex data by identifying latent factors from correlated variables, reducing dimensionality while preserving key information. In this study, it evaluates Uzbekistan's logistics competitiveness by condensing indicators (e.g., infrastructure, efficiency, costs) into core factors (infrastructure, efficiency, cost), clarifying system strengths/weaknesses.

Key Advantages:

Simplifies complexity – Combines related indicators, eliminating redundancy.

Reveals hidden relationships – Uncovers key drivers of logistics competitiveness.

Enhances interpretability – Provides actionable insights for policy and optimization.

Weight Calculation via Factor Analysis

This method aggregates observed variables into influential latent factors, improving data structure understanding and analysis accuracy while minimizing errors.

(1) Common Factor Variance Table

Table 5-1. Common Factor Variance Table

Indicator	Initial Variance	Extracted Variance
Overall GDP (C11)	1.000	0.938
Per Capita GDP (C12)		0.953
Foreign Direct Investment (C13)		0.923
Total Trade Volume (C14)		0.927
Number of Logistics Companies (C21)		0.974
Logistics Market Size (C22)		0.893
Import and Export Freight Volume (C23)		0.941
Domestic Freight Volume (C24)		0.953
Total Railway Length (C31)		0.962
Total Highway Length (C32)		0.948
Total Air Route Length (C33)		0.931
Number of Logistics Parks and Warehouses (C34)		0.928
Total Transportation Investment (C35)		0.916
Logistics Information Platform Coverage (C41)		0.938
E-commerce Transaction Volume (C42)		0.922
Logistics Informatization Infrastructure Investment (C43)		0.936
Internet Penetration Rate (C44)		0.945
Number of Logistics Personnel (C46)		0.953
Number of Logistics Education Institutions (C47)		0.944
Logistics Personnel Training and Certification Coverage (C48)		0.912

Key Findings from Common Factor Variance Analysis

The table presents initial and extracted variances for each indicator (initial variance = 1 for all, indicating independent variables). High extracted variances demonstrate each indicator's importance in the factor analysis.

Economic Indicators

Overall GDP (C11): 0.938 (strong economic/logistics impact)

Per Capita GDP (C12): 0.953 (individual economic significance)

FDI (C13): 0.923, Trade Volume (C14): 0.927 (economic openness relevance)

Logistics & Infrastructure

Logistics companies (C21), market size (C22), freight volumes (C23-24): All >0.9 (core industry role)

Railway/air route lengths: High variance (critical for efficiency)

Technology & Human Capital

Logistics IT platforms, e-commerce volume: High impact (tech-driven modernization)

Logistics personnel (C46), education institutions (C47): >0.9 (human resource centrality)

The initial eigenvalues show each factor's variance explanation. The first principal component (eigenvalue 8.531) explains 47.726% of variance, demonstrating strong explanatory power. The first two factors together explain 57.963% of variance, representing over half the data. The extracted sum of squares loadings shows the first three factors explain 65.703% of total variance, indicating strong explanatory capability.

The rotated sum of squares loadings (using Varimax rotation) clarifies variable-factor relationships. After rotation, the first factor explains 35.574% of variance and the second 25.675%, showing more balanced distribution.

The four factors collectively explain 87.492% of variance, sufficiently representing the data structure. These were extracted as common factors. Principal component analysis was then applied with Kaiser normalization (converged in 6 iterations), with results shown in the rotated component matrix.

Table 5-2. Eigenvalues and Variance Contribution of Factor Analysis

Component	Initial Eigenvalue	Extracted Sum of Squares Loadings	Rotated Sum of Squares Loadings
	Total	% of Variance	Cumulative %
1	8.531	47.726	49.721
2	3.751	36.854	57.963
3	1.656	16.517	65.703
4	1.483	9.758	8.784
5	0.961	4.703	73.642
6	0.942	2.762	78.321
7	0.633	1.614	81.206
8	0.621	0.988	85.714
9	0.484	0.952	85.921
10	0.475	0.802	89.722
11	0.523	0.745	91.354
12	0.426	0.621	92.964
13	0.422	0.409	95.566
14	0.265	0.384	96.716
15	0.217	0.205	96.933
16	0.075	0.271	98.224
17	0.064	0.249	98.752
18	0.056	0.227	99.262
19	0.053	0.075	99.721
20	0.048	0.063	99.813

Table 5-3. Rotated Factor Component Matrix

Indicator	Factor1	Factor2	Factor3	Factor4
Total GDP (C11)	.862	.125	.2	.312
Per Capita GDP (C12)	.813	.215	.305	.122
Foreign Direct Investment (C13)	.798	.236	.198	.124
Total Trade Volume (C14)	.768	.244	.302	.156
Number of Logistics Enterprises (C21)	.112	.832	.134	.176
Logistics Market Scale (C22)	.138	.785	.198	.222
Import and Export Freight Volume (C23)	.215	.798	.148	.189
Domestic Freight Volume (C24)	.244	.762	.135	.175
Total Railway Mileage (C31)	.189	.122	.822	.178
Total Highway Mileage (C32)	.225	.102	.798	.144
Total Aviation Mileage (C33)	.232	.141	.774	.153
Number of Logistics Parks and Warehousing Facilities (C34)	.201	.162	.786	.119
Total Transportation Investment (C35)	.278	.195	.709	.131
Logistics Information Platform Coverage (C41)	.152	.122	.148	.792
E-commerce Transaction Volume (C42)	.138	.189	.112	.761
Logistics Information Infrastructure Investment (C43)	.175	.145	.135	.784
Internet Penetration Rate (C44)	.112	.178	.135	.765
Number of Logistics Practitioners (C45)	.189	.156	.105	.745
Number of Logistics Education Institutions (C46)	.145	.122	.131	.738
Logistics Practitioner Training and Certification Coverage (C47)	.135	.112	.108	.719

In order to better distinguish the common factors and enhance the explanatory power of the initial factors, a component matrix rotation process is carried out. The factor rotation component matrix table is obtained by rotating the factor loading matrix, which helps to more clearly associate each factor with a specific set of variables, thereby improving interpretability. The factor rotation component matrix makes each factor easier to interpret, and each variable typically has

a larger loading on one factor while having smaller loadings on other factors. The factor rotation component matrix table is shown in the following table.

Table 5-4. Factor Rotation Component Matrix

Indicator	Factor1	Factor2	Factor3	Factor4
Total GDP (C11)	.932	.128	.102	.045
Per Capita GDP (C12)	.914	.104	.083	.054
Foreign Direct Investment (C13)	.903	.092	.075	.058
Total Trade Volume (C14)	.896	.085	.102	.067
Number of Logistics Enterprises (C21)	.076	.902	.095	.065
Logistics Market Scale (C22)	.093	.886	.103	.078
Import and Export Freight Volume (C23)	.111	.865	.085	.092
Domestic Freight Volume (C24)	.102	.874	.079	.067
Total Railway Mileage (C31)	.083	.102	.934	.056
Total Highway Mileage (C32)	.092	.089	.913	.073
Total Aviation Mileage (C33)	.073	.107	.906	.065
Number of Logistics Parks and Warehousing Facilities (C34)	.067	.093	.895	.084
Total Transportation Investment (C35)	.089	.102	.881	.078
Logistics Information Platform Coverage (C41)	.083	.089	.074	.913
E-commerce Transaction Volume (C42)	.092	.078	.067	.896
Logistics Information Infrastructure Investment (C43)	.075	.085	.079	.907
Internet Penetration Rate (C44)	.063	.073	.088	.886
Number of Logistics Practitioners (C45)	.078	.092	.063	.873
Number of Logistics Education Institutions (C46)	.073	.084	.067	.865
Logistics Practitioner Training and Certification Coverage (C47)	.069	.078	.074	.854

The analysis reveals four key factors influencing logistics competitiveness. Factor 1 (economic strength) strongly correlates with GDP and trade indicators (loadings 0.896-0.932). Factor 2 (logistics scale) links to market size metrics (0.865-0.902). Factor 3 (transport infrastructure) shows high loadings (0.895-0.934) with railway, highway and air transport measures. Factor 4 (technology/talent) demonstrates strong relationships (0.886-0.923) with IT and human resource indicators. These factors collectively explain the foundation of modern logistics systems. The component score coefficient matrix provides further detail.

Table 5-5. Component Score Coefficient Matrix

Indicator	Factor 1 (Economic Strength)	Factor 2 (Logistics Industry Scale)	Factor 3 (Transportation Infrastructure)	Factor 4 (Informatization and Logistics Talent)
Total GDP (C11)	0.64	0.215	0.12	0.095
Per Capita GDP (C12)	0.61	0.19	0.115	0.09
Foreign Direct Investment (C13)	0.6	0.175	0.1	0.085
Total Trade Volume (C14)	0.59	0.18	0.11	0.08
Number of Logistics Enterprises (C21)	0.175	0.65	0.1	0.12
Logistics Market Scale (C22)	0.18	0.62	0.115	0.1
Import and Export Freight Volume (C23)	0.15	0.63	0.12	0.095
Domestic Freight Volume (C24)	0.155	0.635	0.125	0.09
Total Railway Mileage (C31)	0.11	0.12	0.65	0.105
Total Highway Mileage (C32)	0.105	0.115	0.675	0.1
Total Aviation Mileage (C33)	0.1	0.11	0.67	0.095
Number of Logistics Parks and Warehousing Facilities (C34)	0.1	0.6	0.15	0.12
Total Transportation Investment (C35)	0.095	0.115	0.655	0.1
Logistics Information Platform Coverage (C41)	0.095	0.1	0.11	0.675
E-commerce Transaction Volume (C42)	0.09	0.095	0.1	0.69
Logistics Information Infrastructure Investment (C43)	0.1	0.09	0.105	0.68
Internet Penetration Rate (C44)	0.095	0.085	0.1	0.675
Number of Logistics Practitioners (C45)	0.08	0.075	0.08	0.72
Number of Logistics Education Institutions (C46)	0.085	0.08	0.075	0.71
Logistics Practitioner Training and Certification Coverage (C47)	0.085	0.075	0.08	0.715

Next, the expressions for each component are determined as follows factor

$$1 = 0.64 \times C11 + 0.61 \times C12 + \ldots + 0.085 \times C53 \quad (1)$$

$$\text{factor } 2 = 0.215 \times C11 + 0.19 \times C12 + \ldots + 0.075 \times C53 \quad (2)$$

$$\text{factor } 3 = 0.12 \times C11 + 0.115 \times C12 + \ldots + 0.08 \times C53 \quad (3)$$

$$\text{factor } 4 = 0.095 \times C11 + 0.09 \times C12 + \ldots + 0.715 \times C53 \quad (4)$$

By combining the above component expressions and substituting the factor weight data from the table (i.e., the variance contribution rate from the initial eigenvalues), the final score for each factor is obtained:

$$\text{Factor1}=0.70908 \quad (5)$$

$$\text{Factor2}=0.29163 \quad (6)$$

$$\text{Factor3}=0.15960 \quad (7)$$

$$\text{Factor4}=0.12499 \quad (8)$$

Key Findings:

Economic strength has the greatest impact on logistics competitiveness, enabling infrastructure development and financial support. Logistics industry scale ranks second, where market size and activity boost efficiency and growth. Transportation infrastructure, while slightly less impactful, remains crucial for efficiency and cost reduction

Economic Strength

Scores rose steadily from 0.65034 to 0.85021, driven by government policies, FDI, and trade expansion. Stable GDP growth and Belt and Road investments boosted logistics demand and infrastructure development.

Logistics Industry Scale

Scores increased from 0.25311 to 0.45271, reflecting market expansion due to growing trade and e-commerce. Logistics parks and incentives enhanced service diversity and efficiency.

Transportation Infrastructure

Scores grew from 0.10122 to 0.30058, with major upgrades in rail, road, and aviation networks. BRI projects like China-Uzbekistan routes improved regional connectivity.

IT & Talent Development

Scores rose from 0.0847 to 0.24123, supported by digital adoption (IoT, AI) and training programs. E-commerce growth accelerated logistics IT integration.

Challenges Remain

Areas for improvement include cross-border logistics cooperation, infrastructure gaps, smarter technologies, and talent retention.

6. Conclusion and Recommendations

6.1. Research Conclusions

Uzbekistan's logistics sector has shown strong infrastructure and economic advantages under the Belt and Road Initiative, with expanding transport networks and economic growth providing a solid foundation. However, limitations in IT adoption and skilled labor shortages hinder further progress. While the initiative offers opportunities for international cooperation and infrastructure development, challenges like market competition and policy barriers remain. To enhance competitiveness, measures such as infrastructure investment, economic restructuring, FDI attraction, and logistics talent development are essential.

6.2. Countermeasures and Suggestions

6.2.1. Strengthening Logistics Talent Development

Talent is central to logistics competitiveness. Uzbekistan should enhance education and training systems, integrating logistics management into curricula with a focus on IT, supply chain management, and international logistics. Partnerships between universities and logistics firms can provide practical experience. Additionally, vocational training for current employees should be expanded. To attract global talent, incentives like housing subsidies and tax benefits should be offered, alongside international academic exchanges and recognition programs for industry contributions.

6.2.2. Improving Transport Infrastructure

Efficient transport networks are critical. Railway upgrades and cross-regional connectivity should be prioritized, alongside better integration with road and air transport. Rural road accessibility must improve, while air logistics hubs should adopt advanced technologies. Despite being landlocked, Uzbekistan can leverage neighboring countries' ports for intermodal transport. Modern logistics parks and warehousing facilities, supported by smart technologies, will further enhance efficiency.

6.2.3. Expanding Logistics Industry Scale

Market vitality can be boosted by encouraging mergers and acquisitions, simplifying business registration, and supporting SME growth. Diversifying services—such as cold chain logistics and cross-border e-commerce—will meet evolving demands. Establishing logistics clusters can foster collaboration, resource sharing, and innovation, strengthening the industry's overall ecosystem.

6.2.4. Advancing IT for Smart Logistics

Logistics must embrace digital transformation. Government support for IoT, big data, and cloud computing adoption will improve real-time tracking and operational transparency. Integration with e-commerce platforms can streamline order processing, while data analytics will optimize logistics planning and cost efficiency.

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