



# Analysis of the China-Central Asia Cooperation Based on a Multi-Factor Matrix and EW-TOPSIS Model

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**Abstract.** Central Asia, with its unique geographical location serving as a bridge between Europe and Asia, plays a prominent role in facilitating connections. In order to enhance trade exchanges, economic integration, and regional coordinated development between China and Central Asia, as well as on a broader scale, this paper proposes a comprehensive analysis matrix incorporating multiple factors and constructs an EW-TOPSIS (Entropy Weight - Technique for Order Preference by Similarity to an Ideal Solution) evaluation model to conduct a systematic analysis of the competitiveness of cooperation between major powers and the five Central Asian countries across various dimensions. By objectively determining the weights of various factors through the entropy weight method, and then applying the TOPSIS model to calculate the competitiveness index of cooperation between each country and Central Asia, the research reveals that China performs prominently in multiple evaluation dimensions. This study provides theoretical support for promoting the construction of a closer China-Central Asia community with a shared future.

**Keywords:** Central Asia, Cooperation analysis, Multi-factor matrix, EW-TOPSIS model.

## 1 Introduction

Central Asia serves as both a vital bridge connecting Europe and Asia and a geographical corridor spanning north to south. Endowed with abundant energy reserves and immense market potential, the region holds a positive stance towards integrating into the international trade system and participating in global governance. Since 2023, the five Central Asian countries have experienced a golden era of foreign exchanges, with new development opportunities emerging in bilateral and multilateral relations as well as regional cooperation<sup>[1]</sup>. Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Turkmenistan—are located at the heart of the Eurasian continent, adjacent to East Asia and Western Europe<sup>[2]</sup>, and occupy a total land area exceeding 4 million square kilometers.

With the objectives of deepening interconnectivity, promoting economic and trade development between China and Central Asia, this paper proposes a multi-factor analysis matrix and constructs an EW-TOPSIS-based evaluation model for assessing the

competitiveness of cooperation between major powers and the five Central Asian countries. This model scientifically evaluates the competitiveness of such cooperation in a complex environment, and investigates the choices made by Central Asian nations in terms of their external cooperation and development amidst such complexities.

## 2 Current Development Status of the Five Central Asian Countries

### 2.1 Economic and Trade Situation

In 2021, Kazakhstan's GDP reached US\$197.1 billion, and it grew by 3.1% in 2022. Uzbekistan, with a territorial area of 448,900 square kilometers. In 2022, Uzbekistan's GDP was US\$80.384 billion, representing a year-on-year growth of 5.7%. Kyrgyzstan, which GDP was US\$10.933 billion while Tajikistan's GDP was 115 billion yuan, marking an 8% year-on-year growth. Turkmenistan, an inland country with a territorial area of 491,200 square kilometers A statistical overview of the economic performance of the five Central Asian countries in 2021 is presented in Figure 1.

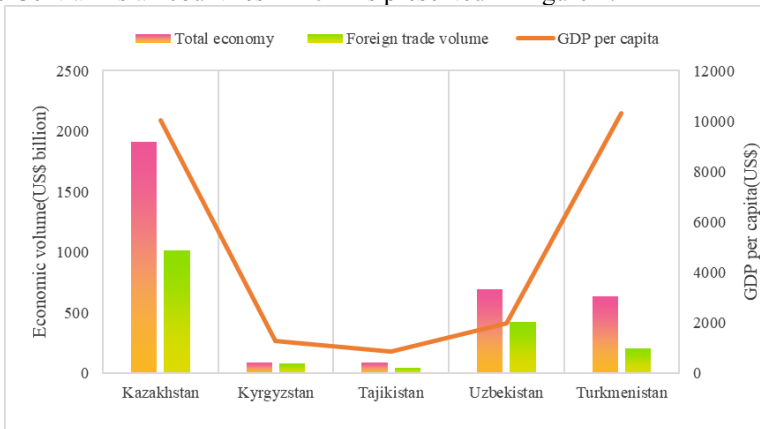


Fig. 1. Statistics on the economic situation of the five Central Asian countries in 2021. (Source: CEIC database, General Administration of Customs website, Ministry of Commerce website.)

Among them, Kazakhstan's abundant oil, natural gas, and mineral resources provide a robust foundation for its economic development, making it one of the most economically developed countries in Central Asia. Turkmenistan, with its abundant oil and natural gas resources, is a significant energy exporter in Central Asia. Its economy is highly dependent on energy exports<sup>[3]</sup>.

### 2.2 Current Status of Transportation Infrastructure

As all five Central Asian countries are landlocked, land transportation serves as their primary means of external communication, with railways and highways being crucial supports for their foreign trade.

Figure 2. depicts the ranking of the five Central Asian countries based on their railway network density in 2021, measured by the length of the railway per 10,000 square kilometers.

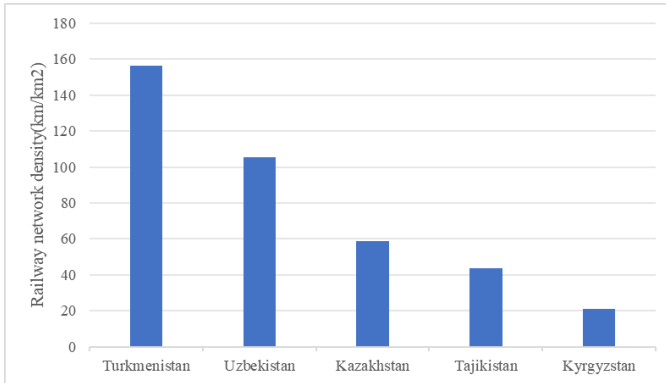


Fig. 2. Comparison of Railway Network Density in Five Central Asian Countries in 2021. (Source: World Bank)

### 3 Multi-factor Evaluation Model

#### 3.1 Multi-Factor Evaluation System

Table 1. Multi-factor evaluation system.

Evaluation Dimensions	Evaluation Indicators	Evaluation Content
Political diplomacy	strategic relations	The level and depth of the strategic relationship between the two sides, reflecting the closeness of the partnership.
	trade volume	The growth of trade volume between the two sides, measuring the scale and growth potential of economic and trade cooperation.
Economic and trade cooperation	trade growth rate	Annual growth rate of bilateral trade volume
	trade cooperation mechanisms	Whether the two sides have signed relevant agreements and the status of their implementation, and assess the level of trade liberalization.
	policy mechanisms	Transportation connectivity planning
	highway cooperation	Land bordering Cross-border highway projects
Transportation cooperation	railroad cooperation	Railroad connectivity Railroad cooperation projects
	aviation cooperation	Number of direct flights
		Air transportation network

To comprehensively analyze and evaluate the current status of cooperation between the five Central Asian countries and major powers, an evaluation index system is constructed based on multiple dimensions, incorporating the expert scoring method to establish a multi-factor evaluation system. Table 1 provides a detailed elaboration of the specific indicators and their meanings.

### 3.2 Central Asian International Cooperation Comprehensive Analysis Matrix

Based on the multi-factor evaluation model indicator system established in Section 3.1, a review of the current status of cooperation mechanisms between the five Central Asian countries and major powers has been conducted<sup>[4,6-8]</sup>, with information collected up to December 31, 2023. The resulting set of matrices representing the Central Asian cooperation mechanisms is presented in Table 2.

**Table 2.** Matrix of cooperation mechanisms in Central Asia.

Region	Political Diplo- macy	Economic And Trade Cooperation	Transportation Cooperation			
			Policy Mechanisms	Highway Cooper- ation	Railroad Cooper- ation	Aviation Cooper- ation
China	"C5+1" Heads of State Cooper- ation, "China + Central Countries" coop- eration mecha- nism	In 2020, China's total import value amounted to USD 1.9303 trillion, of which 0.58% came from Central Asia, 0.43% exported to Central Asia. In 2022, China's trade volume with the five Cen- tral Asian countries reached USD 70.2 billion.	"Belt and Road Ini- tiative", the mecha- nism of ministerial meetings on trans- portation	Borders with Ka- zakhstan, Kyrgyz- stan, Tajikistan; China-Kazakhstan highway, China- Kyrgyz-Ukraine highway	China-Kazakh- stan Railway, China-Kyrgyz- stan-Ukraine Railway, China- European Union Train[5]	The five Central Asian countries have fully re- sumed flights, di- rect flights have been established between Urumqi and Asian coun- tries.
						Memorandum of Understanding on the Construction and Development of the International Multi- modal Transporta- tion Corridor "Rus- sia - Caspian Sea - Turkmenistan - Uz- bekistan - Kyrgyz- stan"
Russia	"C5+1" Cooper- ation	In 2020, the total import value of the Rus- sian Federation was 231.7 bil- lion, of which 2.83483.7 billion, with 4.87% exported to Central Asia. The trade volume with Central Asia was ap- proximately \$30.1 billion.				
USA	"C5+1" Heads of State Cooper- ation	In 2021, the total import value of the United States was US2.933trillion,ofwhich0.071.5901 tril- lion, of which 0.1% was exported to Cen- tral Asia; the trade volume with Central Asia was about US\$3.64 billion.	"Middle Corridor", Partnership for Global Infrastructure Development and In- vestment (PGI)	No direct land borders	No direct land borders	Few direct air routes, mainly connected through transit flights from Europe or the Middle East.

Region	Political Diplo- macy	Economic And Trade Cooperation	Transportation Cooperation			
			Policy Mechanisms	Highway Cooper- ation	Railroad Cooper- ation	Aviation Cooper- ation
India	"C5+1" Heads of State Coopera- tion	In 2021, India imported US\$570.4billion, of which 0.09338,4 billion, with 0.27% exported to Central Asia. The trade volume with Central Asia was approximately US\$1.43 billion. Facilitate the five Central Asian countries to join the International North-South Transport Corridor (INSTC) and the Ashgabat Agreement.	India-Central Asia Joint Working Group on Chabahar Port	No direct land borders	No direct land borders	Fewer direct flights, mainly connected through transit flights from the Middle East or South Asia.
		"C5+1" Foreign Ministers' Cooperation, 'Japan+Central Asia' Dialogue mechanism	In 2021, Japan's total global imports amounted to US\$772.3billion,ofwhich0.09776.3 billion, of which 0.1% was exported to Central Asia; the trade volume with Central Asia was approximately US\$1.47 billion.	Government devel- opment assistance mechanism (ODA)	No direct land borders	No direct land borders
EU	The EU and Central Asia: New Opportunities for a Stronger Partnership	In 2020, the EU imported US\$1.7975 trillion, of which 0.842.3832 trillion, of which 0.4% was exported to Central Asia; the trade volume with Central Asia was about US\$24.63 billion.	Central Asia Regional Economic Cooperation Program (CARECP)	No direct land borders, mainly indirectly through Russia, Turkey and the Caucasus countries.	Trans-Caspian Sea Transportation Route, China-European trains	There are multiple direct flights.

Data source: China Government Website, China Belt and Road Website, WTO IDB & UN Comtrade

Furthermore, the analysis matrix obtained is quantitatively scored on a 100-point scale for the cooperation indicator dimensions between the five Central Asian countries and various countries. This process is presented in Table 3.

**Table 3.** Scoring matrix for cooperation in Central Asia.

Region	Political diplomacy	Economic and trade co- operation	Transportation cooperation			
			Policy Mechanisms	Highway Cooperation	Railroad Coopera- tion	Aviation Cooperation
China	95	90	95	85	95	85
Russia	90	95	95	75	85	95
USA	80	80	75	50	50	75
India	80	70	85	50	50	60
Japan	70	70	65	50	50	60
EU	80	90	75	75	75	95

### 3.3 Evaluation of International Cooperation Competitiveness Between Major Powers and Central Asia based on the EW-TOPSIS Model

#### Determination of Indicator Weights Using the Entropy Weight Method.

This paper adopts the entropy weight method to assign weights to the multi-factor indicators of the Central Asian international cooperation mechanisms.

The entropy weight method determines the weights of evaluation indicators by calculating their information entropy<sup>[9]</sup>. The main steps are as follows.

Initially, normalize the multi-factor matrix, the calculation formula is:

$$x'_{ij} = \frac{x_{ij}-m_j}{M_j-m_j} \tag{1}$$

In the formula,  $x_{ij}$  represents the value of the  $j$ -th evaluation indicator for the  $i$ -th cooperative country ( $i=1, 2, 3, \dots, 6$ ;  $j=1, 2, \dots, 6$ );  $m_j$  is the minimum value of the  $j$ -th indicator; and  $M_j$  is the maximum value of the  $j$ -th indicator.

Following the normalization process, the characteristic proportion of the  $j$ -th indicator under the  $i$ -th cooperative country is calculated:

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^n x'_{ij}} \tag{2}$$

Finally, the weight  $w_j$  for each evaluation indicator is determined using the dissimilarity coefficient. The larger the weight coefficient, the more significant the evaluation indicator is to the overall evaluation result.

$$W_j = \frac{g_j}{\sum_{j=1}^m g_j}, j = 1, 2, 3 \dots, 6 \tag{3}$$

After the calculations using the entropy weight method, the weights of various multi-factor indicators can be obtained as shown in Table 4.

**Table 4.** Weights of multi-factor indicators based on the entropy weight method.

Political diplo- macy	Economic and trade coopera- tion	Policy Mecha- nisms	Transportation cooperation		
			Highway Co- operation	Railroad Co- operation	Aviation Cooper- ation
0.0936	0.1572	0.1014	0.2424	0.2468	0.1587

Based on Table 4, it can be concluded that among the three dimensions of policy, economy, and transportation, transportation cooperation contributes the most significantly to the overall competitiveness of countries.

#### Competitiveness Evaluation of China-Central Asia cooperation based on TOPSIS.

The TOPSIS model is a ranking method that approximates an ideal solution<sup>[10]</sup>. The calculation process is as follows:

Constructing the weighted normalized multi-factor evaluation matrix.

$$V_{ij} = (W_j \cdot Z_{ij})_{6 \times 6}, Z_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^n X_{ij}^2}}, j = 1, 2, \dots, 6 \tag{4}$$

In the formula,  $X_{ij}$  represents a  $6 \times 6$  matrix containing the  $j$ -th value of the  $i$ -th object ( $i=1,2,\dots,6; j = 1, 2, \dots, 6$ );  $Z_{ij}$  is the  $6 \times 6$  standardized matrix; and  $W_j$  is the weight of the  $j$ -th evaluation indicator calculated according to Equation 3.

Calculate the distance of each factor object from the positive ideal solution and the negative ideal solution.

$$S_i^+ = \sqrt{\sum_{j=1}^m (V_j^+ - V_{ij})^2} \tag{5}$$

$$S_i^- = \sqrt{\sum_{j=1}^m (V_j^- - V_{ij})^2} \tag{6}$$

In the formula,  $S_i^+$  represents the distance of each factor object from the positive ideal solution;  $S_i^-$  represents the distance of each factor object from the negative ideal solution.

Calculate the relative closeness of each factor object.

$$C_i = \frac{S_i^-}{S_i^+ - S_i^-} \tag{7}$$

After applying the EW-TOPSIS model to quantify the multi-factor matrix of cooperation between major powers and Central Asia, we can obtain the final competitiveness evaluation index, as shown in Tables 5 and 6.

**Table 5.** Relative closeness of each major power under each indicator.

Region	Political diplomacy	Economic and trade cooperation	Transportation cooperation			
			Policy Mechanisms	Highway Co-operation	Railroad Cooperation	Aviation Co-operation
China	0.0180	0.0286	0.0197	0.0535	0.0579	0.0287
Russia	0.0170	0.0302	0.0197	0.0472	0.0518	0.0321
USA	0.0151	0.0254	0.0155	0.0315	0.0305	0.0253
India	0.0151	0.0222	0.0176	0.0315	0.0305	0.0203
Japan	0.0132	0.0222	0.0135	0.0315	0.0305	0.0203
EU	0.0151	0.0286	0.0155	0.0472	0.0457	0.0321

According to the results presented in two tables above, it can be observed that Russia possesses a traditional influence in economic and trade cooperation with Central Asia, demonstrating robust competitiveness across various dimensions. The European Union, shows certain competitiveness in the transportation sector.

**Table 6.** Final competitiveness evaluation index for each major power.

Region	Competitiveness evaluation index
China	0.9096
Russia	0.7784
USA	0.1532
India	0.1067
Japan	0.0000
EU	0.6375

## 4 Conclusion

Amidst profound changes in the global political and economic landscape, the importance of international cooperation in Central Asia, as a crucial node connecting Europe and Asia, has become increasingly prominent. The multi-factor matrix and EW-TOPSIS evaluation model constructed in this paper comprehensively assesses the current status and potential of cooperation between major powers and the five Central Asian countries. The results indicate that while all major powers exert certain influence in Central Asia, China demonstrates significant advantages across multiple key evaluation indicators, reflecting its strong competitiveness and profound influence in regional cooperation. With further advancement of the Belt and Road Initiative, China and the five Central Asian countries will strengthen their cooperation in transportation, exploring more mutually beneficial and win-win cooperation mode to promote peace, stability, and development in Central Asia and beyond.

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