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Comparative analysis of the efficiency of transportation corridors in Mongolia

Altanbagana Myagmarsuren[1], Urantamir Gankhuyag[1], Tseyenkhand Punsantsogvoo[1,*], Nandin-Erdene Amartuvshin[1], Natsagsuren Bayasgalan[1]

[1]*Institute of Geography and Geoecology, Mongolian Academy of Sciences, Ulaanbaatar 15170, Mongolia*

***CORRESPONDING AUTHOR**
Tseyenkhand Punsantsogvoo
tseyenkhandp@mas.ac.mn
ORCID
0000-0003-1433-3028

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ABSTRACT

The development of transportation corridors is especially important for landlocked countries, as it enhances their capacity to connect internal regions with seaports, markets, and production centers. Within the framework of the Regional Development Concept of Mongolia (2024-2050), vertical and horizontal transportation corridors of transport infrastructure have been identified. For these transportation corridors, it is important to establish the development priority based on a comparative analysis of the efficiency of the regional transport network, and then determine the distribution of construction and investment. Therefore, the purpose of this study is to conduct a comparative analysis of the efficiency of the above-mentioned transportation corridors and establish the priority. The Time-Cost-Distance (TCD) method was employed to evaluate each corridor. Data was collected on the current state of transport infrastructure, as well as the time and cost associated with transportation processes along each corridor. Based on the comparative analysis, the corridors were ranked into three priority groups, with Corridor 3 in the first priority, Corridors 1 and 4 in the second priority, and Corridors 2, 5, and 6 in the third priority. Corridor 3, which is included in the first priority, is the main road corridor of Mongolia. Corridors 1 and 4, which are included in the second priority, are important for the integration of Central and Eastern Asia into regional economic cooperation and demonstrate the importance of developing them first. Corridors 2, 5, and 6, which are included in the third priority, have relatively low economic efficiency compared to other corridors, so they can be developed at a later stage.

KEYWORDS

Transportation corridors, Road networks, Time-cost-distance analysis, Regional development concept of Mongolia.

1. INTRODUCTION

International merchandise trade in Asia has fully rebounded from the effect of global economic crisis and intraregional trade is now growing. It is expected that the trend to continue with China taking the major share of export and import [1]. This continuing trend of trade growth needs a new paradigm to improve efficiency and cost-effectiveness of transportation system[2].

Although significant progress has been made in developing international highways and railways in Asia, many sections of road and rail infrastructure remain underdeveloped and in need of substantial upgrades [3], [4]. Intermodal rail/road freight transport has always been considered as a competitive alternative to its road freight counterpart in the European medium-to long-distance corridors [5].

The Mongolian Parliament approved the Mongolian Regional Development Concept (2024-2050) in 2024 [6] and within its framework, it defined vertical and horizontal axes (corridors) of transport infrastructure. It is of critical importance to assess the efficiency of these transportation corridors within the regional transport network and to establish their development priorities.

A corridor is a linear orientation of transport routes and flows, connecting important locations that act as origins, destinations, or points of transshipment [7]. From a spatial perspective, a transportation corridor can be defined as a geographic area between two points or a segment connecting multiple centers for the movement of people and goods [8]. More broadly, it may also refer to a geographic region that includes tourism-related or potential travel activities [9]. Transportation corridors may be categorized as domestic, international, or transit corridors.

Landlocked countries face additional challenges related to transportation costs and time, as they are far from ports [10]. It is even more important for landlocked countries as intermodalism would improve connectivity of inland area to ports, markets, and production centers [2]. On the other hand, by comparing the efficiency of corridors, it is possible to identify the obstacles faced by a given corridor.

Additional barriers to cross-border movement still exist in Asia because of physical bottlenecks and nonphysical constraints. These inefficiencies in the transport system have an adverse impact on the economic development particularly in landlocked and transit developing countries [2].

In the evaluation of intermodal transportation corridors in Asia [11], a simple time-cost-distance method was used to identify barriers related to corridor efficiency, time, and cost, compared to intermodal transportation corridors connecting Asia and Europe [2].

In the context of Mongolia, although there have been attempts to define transportation corridors from a spatial perspective [12], [13], [14], [15], [16], studies focusing on their transport efficiency remain limited.

Therefore, this article conducts a comparative assessment of transportation corridor efficiency using a simple time–cost–distance method. To achieve this, relevant data were collected on seaports, road networks, border ports, and transportation costs. The corridors were then evaluated and compared based on transport distance, total time, and cost.

This study aims to conduct a comparative analysis of the efficiency of transportation corridors established under Regional Development Concept of Mongolia (2024-2050). By comparing these corridors, it becomes possible not only to rank them but also to support the optimal allocation of infrastructure development and investment resources.

2. RESEARCH METHODS

This study analyzes the transportation corridors established under Regional Development Concept of Mongolia, which connects Asia and Europe, by comparing them based on key factors such as transport distance, travel time, and cost, taking into account the underlying road infrastructure network. The evaluation of transportation corridors includes assessing the physical conditions of infrastructure and transport processes, including intangible barriers along the corridor [11]. By evaluating and comparing the time and costs associated with transportation, handling, and transshipment along and between corridors, including at border ports, the study identifies inefficiencies and constraints in the transport process.

To conduct a comparative analysis, the time-cost-distance method was used, which collects information related to the state of transport infrastructure and the time and cost spent on all transportation processes along the corridor.

To carry out this study, data were collected on roads, railways, intermodal transfer points, ports, and border facilities. Information on the core road and railway networks of transportation corridors was obtained from the Ministry of Road and Transport of

Mongolia, while data on the capacity and throughput of border crossings were acquired from the Mongolian Customs. Information on the throughput capacity of neighboring countries' border ports was sourced from official summaries of border ports in Russia, China, and Kazakhstan. Transport cost data were gathered from the World Bank [17], the China Federation of Logistics and Purchasing, and International freight exchange platforms. Domestic freight transport cost data were obtained from the Ministry of Road and Transport of Mongolia.

Travel time estimates considered the time required for intercity transport and for crossing border ports. Transport cost calculations were based on the average cost of transporting one ton of freight per kilometer across the territories of Russia, China, Kazakhstan, and Mongolia. Transportation costs not only differ between countries, but can also vary significantly across domestic routes within a single country [2]. Nevertheless, considering the differing levels of corridor development, using a country's average transportation cost as a benchmark allows for a more balanced and realistic basis for comparison.

Therefore, using the above average cost values, the total cost value was calculated depending on the length of the transport corridor passing through each country. The total cost was compared to the length of the transport corridor to determine the cost value per unit km of the transport corridor.

The criteria used for comparison—travel distance, travel time, and cost—were normalized based on the standardization method, and an integrated efficiency value was calculated to determine the ranking of each corridor.

3. RESULT AND DISCUSSION

Under Regional Development Concept of Mongolia, six transportation corridors have been approved. These corridors are envisioned as new links extending from Yekaterinburg to coastal ports (**Figure 1**). Therefore, a comparative analysis was conducted to evaluate their contribution to facilitating regional transport connectivity and improving efficiency. For this purpose, four key indicators were used to assess efficiency: the development of basic infrastructure, transport distance, travel time, and transport cost.

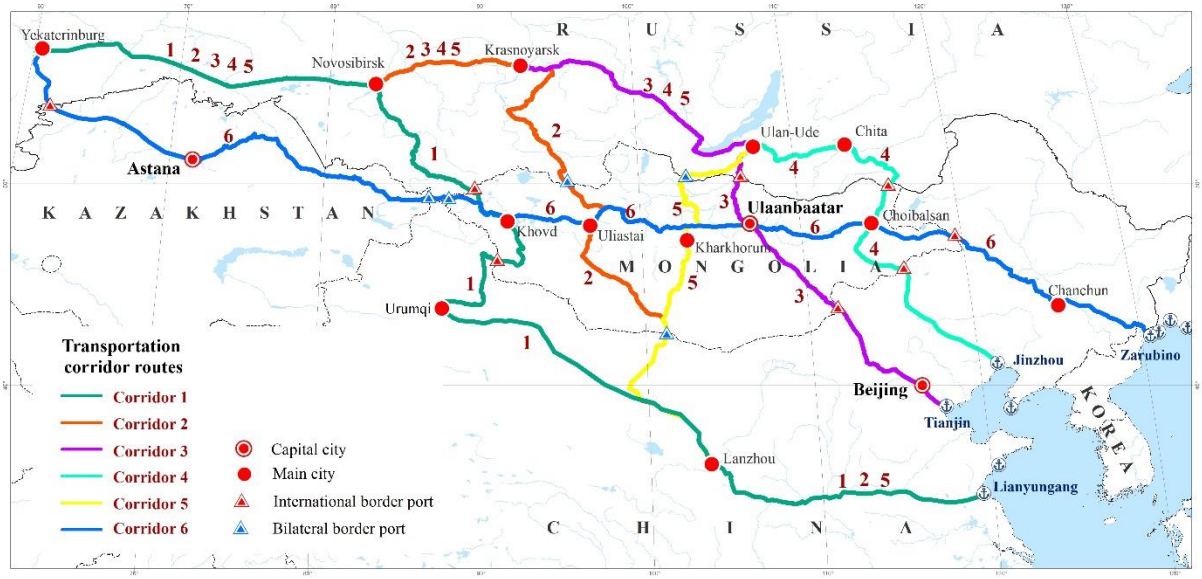

Figure 1. Transportation corridors passing through the territory of Mongolia
/Version proposed within the Regional Development concept of Mongolia (2024-2050)/

Development of Core Infrastructure of Corridors

1. Yekaterinburg – Novosibirsk – Khovd – Urumqi – Lanzhou – Lianyungang corridor

This corridor is notable for its integration with the CAREC Corridor 4A [18] and was fully connected by paved roads in 2023. The total length of the corridor is approximately 7,400 kilometers. It supports regular international and transit freight transport. The route traverses Russia, Mongolia, and China, passing through internationally classified border ports such as Tashanta/Tsagaannuur and Bulgan/Takashiken, ultimately reaching the port of Lianyungang.

2. Yekaterinburg – Novosibirsk – Krasnoyarsk – Uliastai – Lanzhou – Lianyungang corridor

This corridor has been proposed within the framework of Mongolia's national development policy to be aligned with regional transport networks [19]. It spans approximately 7,400 kilometers, with 85% of the road infrastructure currently paved. The route also passes through Russia, Mongolia, and China, and includes bilateral border ports such as Tsagaantolgoi/Artsuur and Shiveekhuren/Sehee, ultimately connecting to the port of Lianyungang.

3. Yekaterinburg – Novosibirsk – Krasnoyarsk – Ulan-Ude – Ulaanbaatar – Beijing – Tianjin corridor

This corridor represents Mongolia's primary transport backbone and serves as the shortest route connecting Asia and Europe. It is a central axis of Mongolia's transport network, aligned with the Belt and Road Initiative, CAREC, and regional cooperation in Northeast Asia. The total length of the corridor is approximately 6,200 kilometers, and it supports domestic, international, and transit freight movements on a regular basis. The route passes through Russia, Mongolia, and China, crossing international border ports such as Naushki/Sukhbaatar, Khiagt/Altanbulag, and Zamyn-Uud/Erenhot, continuing on to Beijing and finally reaching the port of Tianjin.

4. Yekaterinburg – Novosibirsk – Krasnoyarsk – Ulan-Ude – Chita – Choibalsan – Jinzhou corridor

This proposed corridor, part of Mongolia's development policy framework, is intended to be integrated with regional transport networks and reflects growing regional cooperation in Northeast Asia [20]. The total length of the corridor is approximately 6,600 kilometers, with 89% of the road network currently paved. The route passes through Russia, Mongolia, and China, and includes international border ports such as Solovyevsk/Ereentsav and Bichigt/Zuun Khatavch, ultimately linking to the port of Jinzhou.

5. Yekaterinburg – Novosibirsk – Krasnoyarsk – Ulan-Ude – Kharkhorum – Lanzhou – Lianyungang corridor

This corridor has been proposed within the framework of Mongolia's national development policy and is intended to be integrated with regional transport systems. The total length of the corridor is approximately 8,200 kilometers, with 80% of the road network currently paved. The route traverses Russia, Mongolia, and China, passing through bilateral border ports such as Ainek Gol/Baga-Ilenkh and Shiveekhuren/Sehee, continuing through Lanzhou and ultimately connecting to the port of Lianyungang.

6. Yekaterinburg – Astana – Khovd – Uliastai – Ulaanbaatar – Choibalsan – Changchun – Zarubino corridor

This corridor is also proposed under Mongolia's national development policy as part of efforts to align with regional transport networks. The total length of the corridor is approximately 7,200 kilometers, with 79% of its roads currently paved. The route passes through Russia, Kazakhstan, Mongolia, and China, crossing border ports such as Troitsk/Kairak, Arshaty/Khukh-Ereg, and Sumber/Arxan, before continuing through Changchun and reaching the port of Zarubino.

Comparative Analysis of Travel Distance

A comparison of travel distances among the transportation corridors from Yekaterinburg to seaports indicates that Corridor 3 is the shortest route, being approximately 500 to 2,100 kilometers shorter than the other corridors. Corridor 4 appears to be the next shortest alternative in terms of travel distance. In contrast, Corridor 5 has the longest travel distance among the six corridors analyzed (Figure 2) .

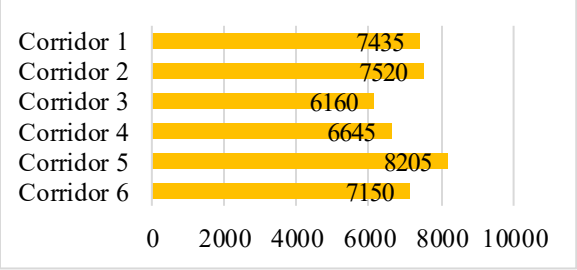

Figure 2. Comparison of travel distances between transportation corridors, km

Based on transport distance, road surface conditions, and estimated border crossing times, a comparative analysis of travel duration shows that Corridor 3 is the fastest option, with a total estimated travel time of 90.8 hours, which is 8.5 to 28 hours shorter than the other corridors (Figure 3) . Corridor 1 appears to be the second most time-efficient route among the alternatives.

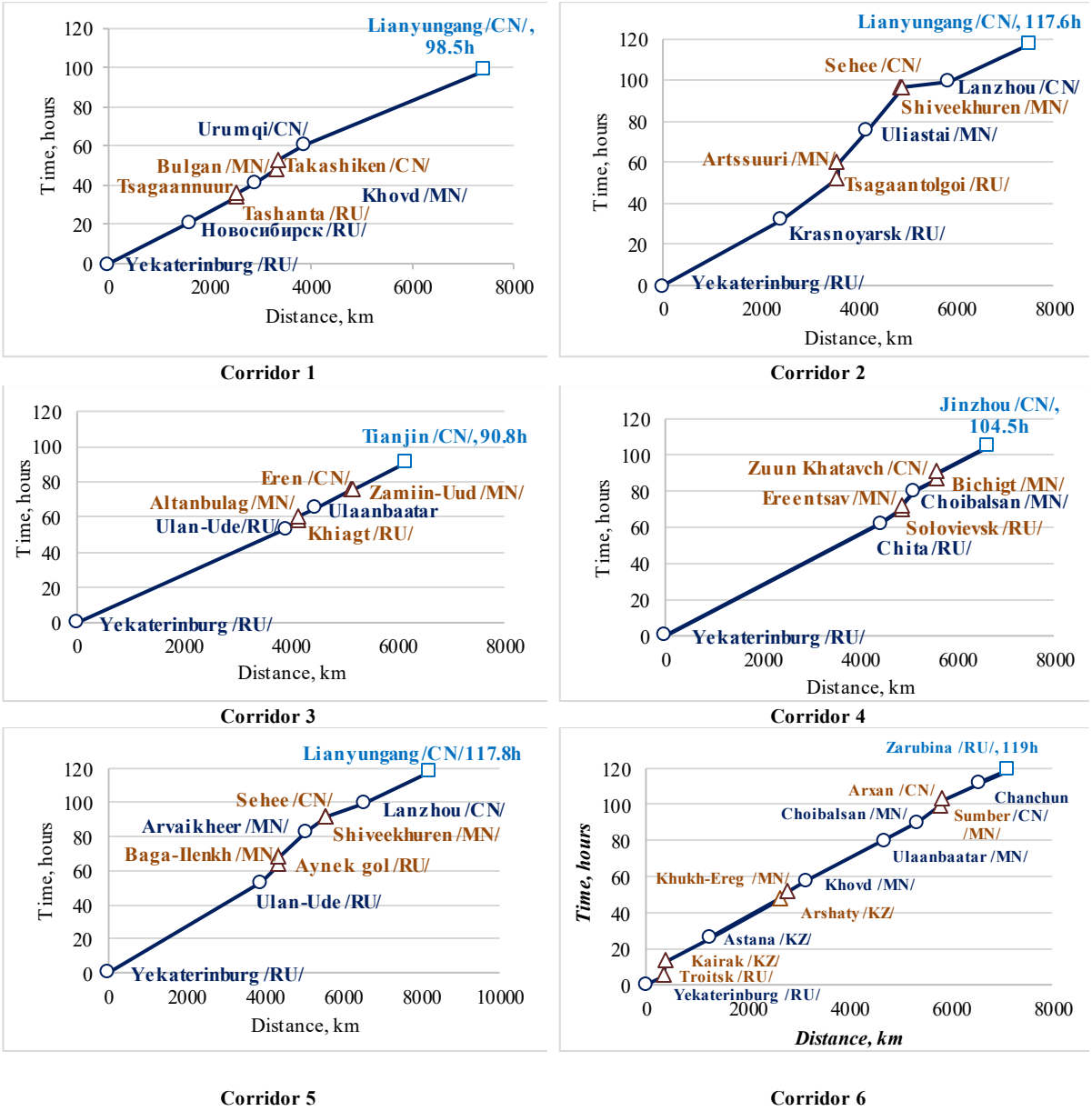

Figure 3. Travel distance and time of transportation corridors
(○ **Yekaterinburg** - Cities, Δ **Sehee** - Border port, □ **Tianjin** - Sea port)

Comparative Analysis of Cost

Based on the costs per ton-kilometer of freight transport and transportation distances of the above-mentioned transportation corridors, calculations were made. These calculations are based on the rates per ton-kilometer for the countries shown in **Table 1**.

Table 1. Costs for transporting 1 ton of freight per kilometer by country, USD

Countries	Road freight costs (tonn/km)	Source
Russia	0.098$	World bank [17]
China	0.069$	CEIC Data[1]
Kazakhstan	0.63$	International Freight Exchange Platform[2]
Mongolia	0.114$	[21][3]

[1] https://www.ceicdata.com/en/china/price-monitoring-center-ndrc-36-city-monthly-avg-service-charges/cn-service-charges-36-city-avg-road-freight-carried-interprovincial-routine-full-carload
[2] International Freight Exchange Platform, https://Della.eu/
[3] "Approval of Norms / Norms for Estimating the Cost of Road and Road Facility Construction and Repair Works", Annex 4 of

According to this assessment, Corridor 1 has the lowest average cost of transporting 1 ton of freight per kilometer, at 0.084 USD. Corridors 2 and 5 have an average cost of 0.091 USD per ton-kilometer, which is approximately 0.003–0.004 USD lower than Corridors 3 and 4. However, Corridor 6 has the highest transportation cost at 0.26 USD, as shown by the study (Figure 4).

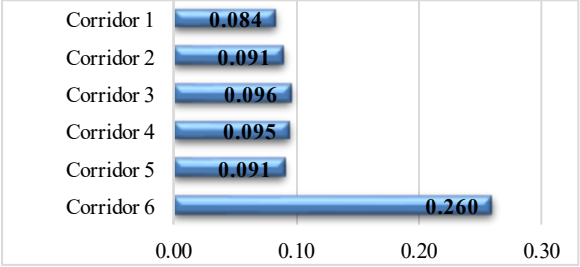

Figure 4. Average cost of transporting 1 ton of freight per kilometer along transportation corridors, USD

In terms of transportation distance, Corridors 3 and 4 are relatively shorter. Regarding travel time, Corridors 3 and 1 offer the possibility of shorter durations. In terms of transportation cost, Corridors 1, 2, and 5 provide opportunities for lower-cost transport compared to the other corridors.

Based on the comparative analysis, the corridors were ranked into three priority groups, with Corridor 3 in the first priority, Corridors 1 and 4 in the second priority, and Corridors 2, 5, and 6 in the third priority (Table 2).

Table 2. Transport corridor priority

	Distance, km	Normalized value	Time, hours	Normalized value	Cost, per km/$	Normalized value	Integrated value	Priority
Corridor 1	7435	0.38	98.5	0.73	0.084	1.00	0.70	**II**
Corridor 2	7520	0.33	109.6	0.33	0.091	0.96	0.54	**III**
Corridor 3	6160	1.00	90.8	1.00	0.096	0.93	0.98	**I**
Corridor 4	6645	0.76	100.5	0.66	0.095	0.94	0.78	**II**
Corridor 5	8205	0.01	117.8	0.04	0.091	0.96	0.33	**III**
Corridor 6	7150	0.52	119	0.01	0.260	0.01	0.17	**III**

4. CONCLUSION

Among Mongolia's transportation corridors, Corridors 1 and 3 have road networks that meet international standards and are regularly used for domestic, international, and transit transportation. In contrast, the road infrastructure of the other corridors is incomplete, with some sections still under construction.

Based on the research findings, Corridor 3—ranked in the first priority—is a key road transportation corridor of Mongolia. Corridors 1 and 4, ranked in the second priority, play an important role in integrating with regional economic cooperation in Central and Northeast Asia and should be prioritized for development.

Corridors 2, 5, and 6, which are ranked third priority, are less efficient than other corridors based on time-cost-distance analysis and could be developed at a later stage.

Although Corridor 2 has a short transportation distance and low cost, the travel time is relatively long due to the current state of road and border checkpoint development. For Corridor 5, despite the lower transport cost, the relatively underdeveloped border infrastructure and longer route contribute to extended transportation times. As for Corridor 6, it has relatively high transportation costs and low efficiency, according to the study.

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