AN OVERVIEW OF TRANSPORT LOGISTICS IN KAZAKHSTAN: FOCUS ON THE CASE OF ASTANA

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Abstract: Kazakhstan's strategic location as a landlocked nation between Europe and Asia makes it a key node in regional transport corridors. Astana, the capital city, exemplifies both the challenges and opportunities of urban logistics transformation in the face of rapid urbanization. This article offers a comprehensive analysis of transport logistics in Astana, applying spatial modeling, graph theory, and logistics metrics to assess infrastructure accessibility and flow efficiency. The study provides insight into infrastructure planning, policy reform, and technological integration necessary to transform Astana into a modern logistics hub. Charts and figures support the analysis, emphasizing performance indicators, traffic bottlenecks, and optimization strategies.

Keywords: Kazakhstan, transport logistics, Astana, urban infrastructure, logistics polarity, graph theory, freight flow, route optimization, smart transport systems, urban planning

1. Introduction

Kazakhstan serves as a key logistics corridor in Eurasia, acting as a land bridge for China-Europe trade. Astana, as the political and administrative center, is at the forefront of the nation's efforts to modernize its transport logistics systems. However, the city faces significant infrastructure challenges. Rapid population growth, unbalanced urban expansion, and outdated logistics hubs have strained the existing systems. To address these issues, this paper investigates the structure of Astana's logistics networks using spatial analysis, infrastructure indicators, and computational modeling.

2. Urbanization and Logistics Challenges

Astana has grown rapidly from a modest administrative center to a city with over 1.5 million residents. This growth has introduced challenges in freight movement, passenger mobility, and logistics coordination. Infrastructure congestion is especially evident in core urban areas where logistic demand and residential density intersect. Peripheral districts remain underserved, highlighting the need for rebalancing resources and introducing smart mobility systems.
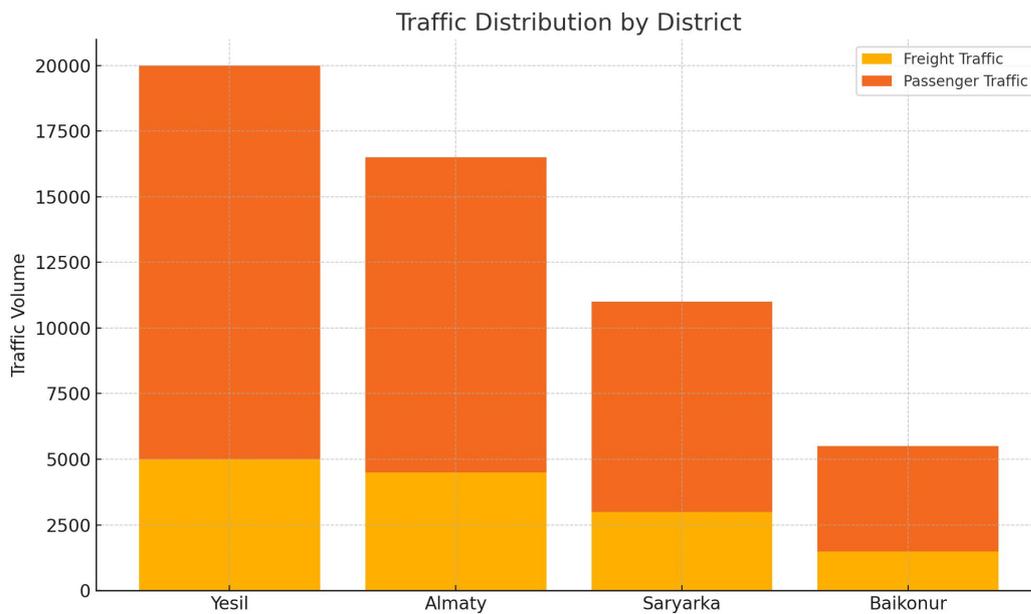
Figure 1. Freight and passenger traffic distribution across Astana's main districts.

3. Methodology

The study adopts a multi-dimensional methodology combining spatial modeling, statistical data from 2021–2023, and graph-theoretic analysis. The city is divided into meso-districts and modeled as a network of nodes and edges. Each node represents a logistics hub or facility, and edges represent connectivity routes. Logistic polarity scores were used to assess access inequality, and Dijkstra's algorithm was applied for route optimization. The results inform the strategic redistribution of logistics capacity and road infrastructure planning.
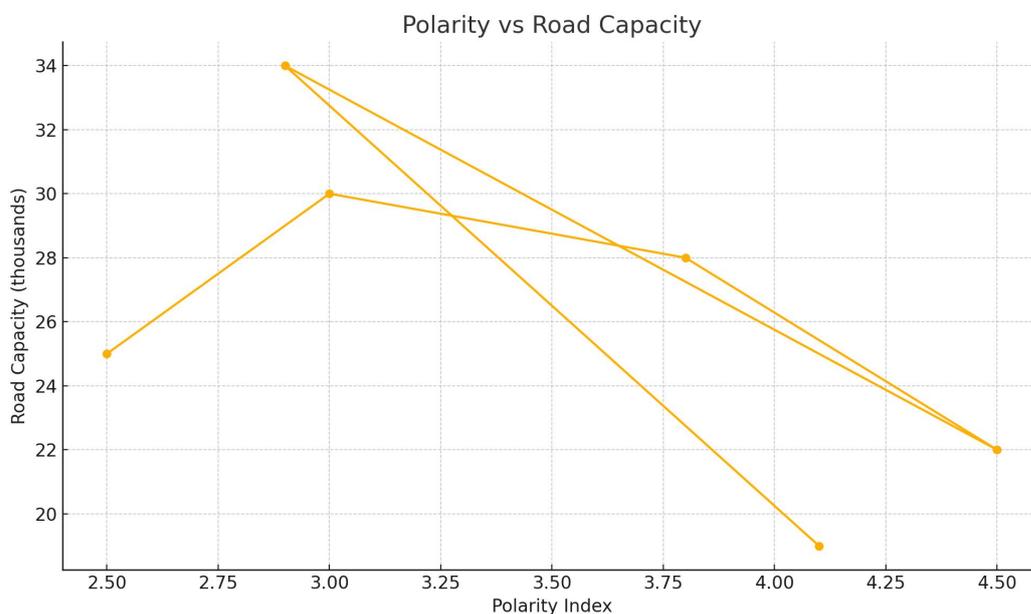

Figure 2. Correlation between logistics polarity and road network capacity.

4. Results

Graph theory analysis revealed central meso-districts suffer from congestion while peripheral areas lack access to key logistics facilities. Polarity scores showed strong correlation with infrastructure concentration and route density. Optimization algorithms suggested that reorganizing freight terminals to outer districts could reduce travel times by 18–22%. Visual data confirmed that a balanced approach to logistics planning can significantly improve performance and reduce congestion hotspots.Astana, formerly known as Nur-Sultan, is undergoing a strategic transformation driven by government-backed infrastructure programs. The city has a projected

population increase to 2.5 million by 2035, accompanied by a 67% rise in motorization levels.The current urban layout is monocentric, but the 2035 general plan emphasizes transitioning to a polycentric model to distribute congestion and enhance access. The roadmap includes expanding the street network density from 4.4 km/km² to 5.2 km/km², and raising the number of multilevel automobile interchanges from 24 to 41. Data from the Bureau of National Statistics indicates that between 2021 and 2023, Astana experienced a 12.3% annual increase in freight turnover, a 3.5% rise in passenger traffic, and a 40.6% surge in tourist flows. However, disparities remain stark. The Logistics Performance Index ranks Kazakhstan 79th globally, and infrastructure access is unevenly distributed among Astana's 21 meso-districts. Urban congestion is directly tied to poor internal street connectivity within meso-districts. Many buildings lack direct road access, funneling all traffic to peripheral arterial roads. This bottleneck effect leads to traffic pile-ups, reduced efficiency in freight delivery, and increased environmental costs from vehicle emissions.This article builds on expert assessments and graph-theoretical modeling to map the polarity of meso-districts. High-polarity districts show strong interconnections and logistic capacity but also face the highest congestion. Peripheral districts, despite availability of land resources, remain underutilized due to limited road linkages and public investment. The findings underline the importance of integrating transport planning with urban development, institutional zoning, and ecological considerations.

5. Strategic Recommendations

- Expand logistics terminals outside high-density areas.
- Establish multimodal hubs near ring-road junctions.
- Integrate river freight along the Ishim River.
- Implement intelligent transport systems (ITS) for real-time traffic optimization.
- Use predictive modeling to guide new infrastructure projects.

6. Conclusion

This paper demonstrates the critical importance of graph-based modeling and spatial analysis in logistics infrastructure planning. Astana's rapid development demands a strategic realignment of freight and passenger logistics systems. Future infrastructure investments should focus on accessibility, sustainability, and smart integration to meet urban demands and economic goals.

7. Kazakhstan's Role in Eurasian Logistics Corridors

Kazakhstan is a critical node in Eurasian logistics, functioning as a bridge for East-West and North-South international trade routes. The country participates in the Trans-Caspian International Transport Route (TITR), also known as the Middle Corridor, which offers a land-based alternative to maritime shipping routes between China and Europe. Additionally, Kazakhstan's integration into the Belt and Road Initiative (BRI) has led to infrastructure upgrades such as expanded railways, logistics terminals, and digital customs systems. Key infrastructure includes the Khorgos Gateway, Aktau Port, and Dry Port facilities, which serve as critical freight handling and transshipment hubs.

Table 1. Comparative logistics indicators among selected regional economies (World Bank, 2023).

Country	LPI Score (2023)	Road Quality Index	Freight Efficiency Rank
Kazakhstan	2.48	3.1	79
Uzbekistan	2.61	3.5	71
Russia	2.85	3.8	51
Turkey	3.15	4.0	34

8. Environmental Sustainability in Urban Logistics

Transport logistics significantly contributes to urban emissions and air pollution, especially in cities like Astana where freight and passenger flows are concentrated in a limited number of corridors. Integrating green logistics practices—such as promoting electric delivery vehicles, consolidating cargo operations, and expanding non-motorized delivery options—can reduce carbon emissions and fuel consumption. Urban consolidation centers, shared delivery networks,

and zoning for logistic hubs away from residential districts also contribute to improved environmental outcomes.

9. Smart Transport Technologies

Astana's smart city agenda includes the deployment of Intelligent Transport Systems (ITS) to enhance traffic monitoring, predictive congestion management, and logistics automation. ITS components such as traffic sensors, real-time freight tracking, and urban control centers are being introduced to synchronize logistics operations with urban mobility needs. These systems allow for dynamic route adjustments, real-time delivery updates, and integration with city-wide data platforms for better decision-making.

10. Case Study: Khorgos Gateway

Khorgos Gateway on the Kazakhstan-China border is one of the largest dry ports in the world. It serves as a key entry point for Eurasian rail traffic. The terminal handles containerized cargo that connects Central Asian markets with China and Europe. Its infrastructure includes automated cranes, customs warehouses, and rail transfer stations that enable rapid processing. Lessons from Khorgos highlight the need for strong policy coordination, international partnerships, and continuous investment in infrastructure to support logistics ecosystems.

11. Human Capital and Logistics Workforce

A well-trained logistics workforce is crucial for operational efficiency. In Kazakhstan, universities and technical institutions are beginning to offer specialized training in logistics management, supply chain analytics, and transport economics. However, there remains a skill gap in areas such as customs digitization, intermodal logistics, and urban freight planning. Government and private sector collaborations are essential to align curriculum with market needs and expand professional certification programs.

12. Conclusion and Outlook

Astana's transport logistics landscape reflects both its growing regional importance and the structural gaps that limit operational efficiency. A multi-pronged strategy integrating infrastructure upgrades, policy reform, sustainability, and education will help Kazakhstan evolve into a major logistics hub. Smart city integration and regional cooperation are expected to shape the next decade of logistics development, with Astana serving as a model for Central Asian urban transformation.

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