Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 2, 374-383
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i2.4491

Government strategy for enhancing the infrastructure of international freight railway corridors: Economic and strategic considerations

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Abstract: The article examines the state strategy for developing the infrastructure of international freight railway corridors in the European and Asia-Pacific regions from 2022 to 2023. It considers the impact of public investment on the formation of infrastructure projects through macroeconomic analysis. It describes programs that help optimize freight transport and stimulate trade development between continents. Public investment in the infrastructure of railway corridors in the EU has increased by 12% over the past five years, indicating a strategic interest in their further development. The article highlights the essence of international partnership and trade cooperation based on foreign investment to modernize railway networks. Special attention is paid to the strategic infrastructure goals for logistics corridors and transport hubs. The role of railway corridors passing through China and the European Union territory is identified. The competition between regions for leadership in transit hubs, economic influence, and control of transport corridors is investigated. At the micro level, trends in the formation of modal transport and the construction of heavy railway infrastructure are analyzed. The efficiency of the G7 countries in increasing the capacity of freight networks is studied. The problems of the states with regulatory protectionism measures have been identified. The article provides a comparative analysis of the leading companies in global freight corridors that are of strategic importance for the functioning of the economy.

Keywords: *Air transport, International freight railway corridors, Multimodal transport, Transport and logistics system, Transport infrastructure.*

1. Introduction

The creation of international railway corridors is a critical element of integrating the global transport system, providing logistics for freight transport between continents in recent decades. Historically, the process of forming railway corridors began in the nineteenth century, when the first transcontinental railways facilitated the emergence of industrial centres. A systematic approach to forming international railway corridors became possible in the second half of the twentieth century, namely after the 1970s when the European Economic Community was formed. The operation of the Trans-Siberian Railway, the New Silk Road and Pan-European Transport Corridors in Europe resulted from many years of international cooperation. The European Commission and the International Union of Railways played a significant role in this process. They coordinated the standardisation of transport infrastructure, harmonised technical requirements and simplified customs procedures. By 2020, the

History: Received: 15 November 2024; Revised: 16 January 2025; Accepted: 16 January 2025; Published: 29 January 2025
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global railway network involved more than 12 critical transcontinental freight corridors, covering more than 70% of trade between Europe and Asia. It has created new opportunities for attracting foreign investment to strengthen transport and logistics systems in urban agglomerations.

The development of modern scientific technologies creates positive prospects for international freight transport through multimodal transport systems. Following the Covid-19 pandemic in 2020, the integration of information technology into railway systems accelerated. In the United States, China and most European countries, this has led to the automation of cargo flow management, which has increased the profitability of designed logistics processes by 20%. The introduction of extensive data-based management systems has made it possible to track train movements in real-time, optimise routes and reduce transportation costs. An essential part of the process was the construction of multimodal transport and logistics centres that integrate different modes of transport - rail, road, sea and air. The main goal is to reduce delivery times and increase the capacity of corridors. The respective cargo centres are actively developing in the ports of Rotterdam and Shanghai, which are global hubs for the transhipment of containers between rail and sea routes. In the long term, developing digital technologies will further integrate railway corridors into global supply chains, strengthening their competitiveness in the global market.

2. Literature Review

The study of international freight rail corridors has remained relevant for several decades, given their critical role in the global economy. The growing attention to this topic has been observed since the beginning of 2020 when globalisation increased international freight traffic due to the pandemic. According to the study by Ashimova, et al. [1] railway corridors like the New Silk Road are strategic elements of international trade, as they provide transportation of goods between China and Europe. The authors Cebeci, et al. [2] note that the Chinese initiative "One Belt, One Road" has significantly influenced the development of railway infrastructure in Central Asia and Eastern Europe.

Researchers Torres Mosquera, et al. [3] studied a sample of European Union countries, highlighting the role of international railway corridors in supporting economic integration. According to Qi, et al. [4] the development of TEN-T (Trans-European Transport Network) corridors aims to reduce logistics costs and increase the competitiveness of the European region in the global market. International corridors create conditions for more efficient transport of goods between EU member states and neighbouring countries, according to Tsimoshynska, et al. [5]. An article by Engesser, et al. [6] showed that the Rhine-Alps and Baltic Sea-Adriatic have become key within the European transport strategy.

According to Thums, et al. [7] public policy for developing railway corridors is the basis for sustainable economic growth. Chang and Kim [8] emphasise that managing urban and global transport networks significantly reduces logistics costs due to automation. They note the importance of integrating multimodal solutions to improve freight efficiency [8].

Yermachenko, et al. [9] analysed the economic aspects of railway infrastructure development. They emphasise the importance of cooperation between the public and private sectors to ensure the financing of large-scale infrastructure projects. Their findings show that attracting private capital can reduce the budgetary burden on the state. In 2023, the authors examined the role of digital technologies in ensuring transparency of railway network management processes [9].

Kazakhstan plays a vital role in developing railway infrastructure, as evidenced by Karlova and Payurova [10] who emphasise the strategic importance of Kazakhstan as a transit hub between China and Europe. Kazakhstan is investing in modernising its railway lines to increase its role in international freight transport, according to Kumar [11]. Similar conclusions are drawn by Arsawan, et al. [12] who analyses the role of developed countries in global transport corridors and their efforts to create new rail links to support their growing economies.

The study by Tello [13] on the role of the United States in global freight transport points to the strategic importance of American railway corridors. According to Suastrini [14] US rail networks carry

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 2: 374-383, 2025
DOI: 10.55214/25768484.v9i2.4491

more than 50% of traffic to the Pacific region, which allows America to maintain its export and import capabilities at a high level.

Researchers Godinho, et al. [15] argue that innovative technologies in multimodal solutions determine factors in international railway corridors. Their findings emphasise modern information systems' importance in optimising transport processes [15].

Thus, modern scientific research emphasises the importance of public policy, international cooperation, and innovation in developing international freight rail corridors.

The article aims to identify how government policy has influenced the development of international freight rail corridor infrastructure. The focus is on changes in the economic aspects of financing and strategic approaches to transport network management. The study focuses on the need to understand the impact of the G7 countries on the efficiency of logistics processes and international trade. The article analyses how government initiatives adapt to the growing demand for digital development after the Covid-19 pandemic. The study uses a systematic approach based on economic, political and technological factors that directly impact the development of railway infrastructure.

3. Materials and Methods

The research methodology is based on the analysis of indicators of international freight railway corridors and the level of investment in transport projects. The article applies statistical analysis to assess infrastructure projects in terms of their economic and strategic nature. The impact on global logistics chains was forecasted by identifying long-term strategies for building railway corridors until 2030. The sample includes regions of strategic importance in developing rail freight corridors, namely: China, the European Union, Kazakhstan, Germany, Poland, India and the United States of America. They were selected based on their economic and political influence on the global freight market.

The first step is to describe the existing international freight railway corridors. Next, a comparative analysis of freight traffic indicators and the share of revenues of railway corridors in the selected regions is carried out. The main focus is on European countries, where the volume of freight traffic, delivery time and economic efficiency of using railway infrastructure compared to other modes of transport are assessed. For this purpose, a content analysis method is used, using data from the International Union of Railways (UIC) and the European Commission for 2022-2023.

The next stage involves an assessment of strategic projects in the United States, China, India and other countries with a significant share of international railway corridors on a global scale. Scenario forecasting is used to outline future trends in railway infrastructure development. An important factor is the analysis of the One Belt, One Road project initiatives, the Trans-Siberian Railway and several other transport corridors in the European Union and Central Asia. The main goal of this stage is to determine the potential impact of each project on global logistics chains and to strengthen the political positions of the G7 member states.

The study includes a structural and functional analysis of the largest companies that play an essential role in forming international railway corridors. These companies include Deutsche Bahn, Indian Railways, China Railway and Union Pacific. The article analyses their contribution to developing the global freight transport infrastructure using the market analysis method. The deductive method determines the impact on the optimisation of logistics processes and ensuring competitiveness in the international market. Particular emphasis is placed on corporate innovations in the relations between Europe, China, and the United States, which are prominent participants in the digitalisation of railway systems. The main aspects of implementing multimodal solutions for the automation of transportation management are revealed. The article's methodology is based on a multi-level approach to analysing international railway corridors' infrastructure and economic parameters. The article uses forecasting methods and assesses the role of critical companies in forming the global logistics system, which made it possible to present the results of the development of international transport infrastructure.

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4. Results

The formation of international railway corridors is a complex process due to the deterioration of relations between the US and China since 2016. However, cooperation between countries with different economic and political systems has intensified due to the global economic downturn in 2019–2020 due to the spread of the Covid-19 pandemic. The key players in developing international railways are China, the European Union, Russia, Kazakhstan, India and the United States. The One Belt, One Road initiative, launched in 2013, has become the main driving force behind the development of railway corridors between China and Europe. In 2022, the EU and China signed a new agreement to expand their joint railway network to improve trade in raw materials, including metals and energy. The agreement envisages significant investments in modernising existing routes and expanding infrastructure in Central Asia, particularly Kazakhstan, which is essential as a transit hub for goods between the East and the West. Infrastructure projects in the European region are receiving significant support from the International Monetary Fund, which is helping to expand their geopolitical role. World Bank researchers note that cooperation between countries in the strategic areas of transport and logistics will help ensure stable economic growth by optimising international supply chains. The process of developing freight railway corridors is shown in Figure 1.

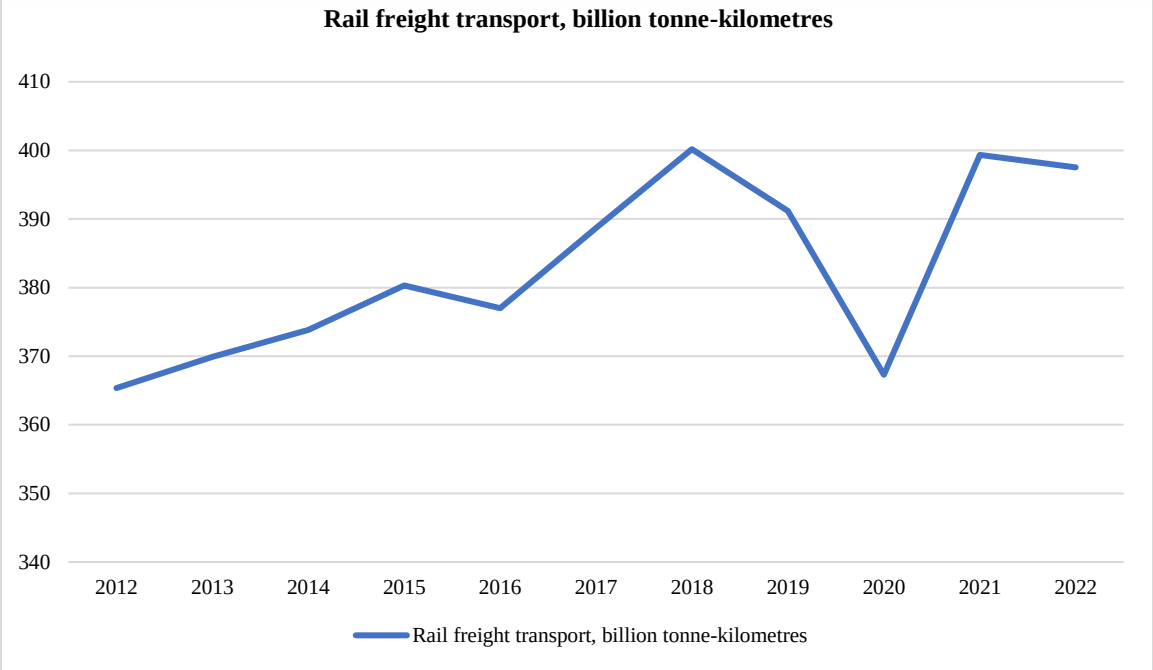

Figure 1.
Rail freight transport for significant enterprises, EU, 2012–2022.
Source: Compiled based on [16].

Despite the global economic slowdown caused by the COVID-19 pandemic in 2020, when rail traffic fell by 20%, the construction of new railway lines continued to grow. This was driven by the need to support the implementation of the G7 economic contracts concluded by 2025. During the pandemic, rail transport proved to be more stable than other modes of transport, such as air travel. Air transport has suffered significant losses due to restrictions on international flights and lower demand for passenger traffic. At the same time, the role of multimodal transport systems, which combine rail, road and air routes to optimise freight transport, has increased. Higher energy efficiency over long distances and the ability to transport large volumes of cargo can reduce CO_2 emissions by 10-15%, making it environmentally attractive compared to air travel. In 2021, new multimodal centres emerged in Europe,

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 2: 374-383, 2025
DOI: 10.55214/25768484.v9i2.4491

namely in Germany and Poland. They have strengthened integration between different modes of transport, increasing the efficiency of long-distance transport.

The change in logistics routes was primarily driven by introducing digital technologies in planning new infrastructure projects. Since 2020, the development of big data technologies has made it possible to forecast traffic flows with an accuracy of up to 90%, enabling the automation of railway route management. As part of a government agreement between the EU and China in 2021, new methods of railway construction using composite materials were introduced. They ensure infrastructure durability and reduce maintenance costs. In Germany, nanomaterials were used to strengthen tracks, which reduced repair costs by 15% compared to traditional materials. Kazakhstan has introduced a digital railway infrastructure monitoring system that allows real-time monitoring of track conditions and prevention of emergencies. The general distribution of resource transportation based on the most significant freight traffic in international transport corridors is shown in Figure 2.

As of 2023, 28.7% of cargo flows were goods that cannot be accurately identified. This is typical for transit traffic of large cargoes, as they contain a variety of categories of goods. The second most important resource is metal ores, which accounted for 11.7% of total traffic. This trend is explained by the high demand for resources in the industry in Germany and Poland, which import ores from Kazakhstan and East Asia. Coke and petroleum products were up 10%, reflecting stable demand for energy despite a drop in production due to restrictions on oil exports from Russia in 2022. Coal and crude oil account for 9% of the total, which is significant for China and India, and they actively increase energy imports to support their industrial capacity. Steel and aluminium accounted for 8.1% of the volume of shipments, while agriculture and chemicals accounted for 6.7% and 6.3%, respectively. This reflects the need to supply food and chemicals to various industries.

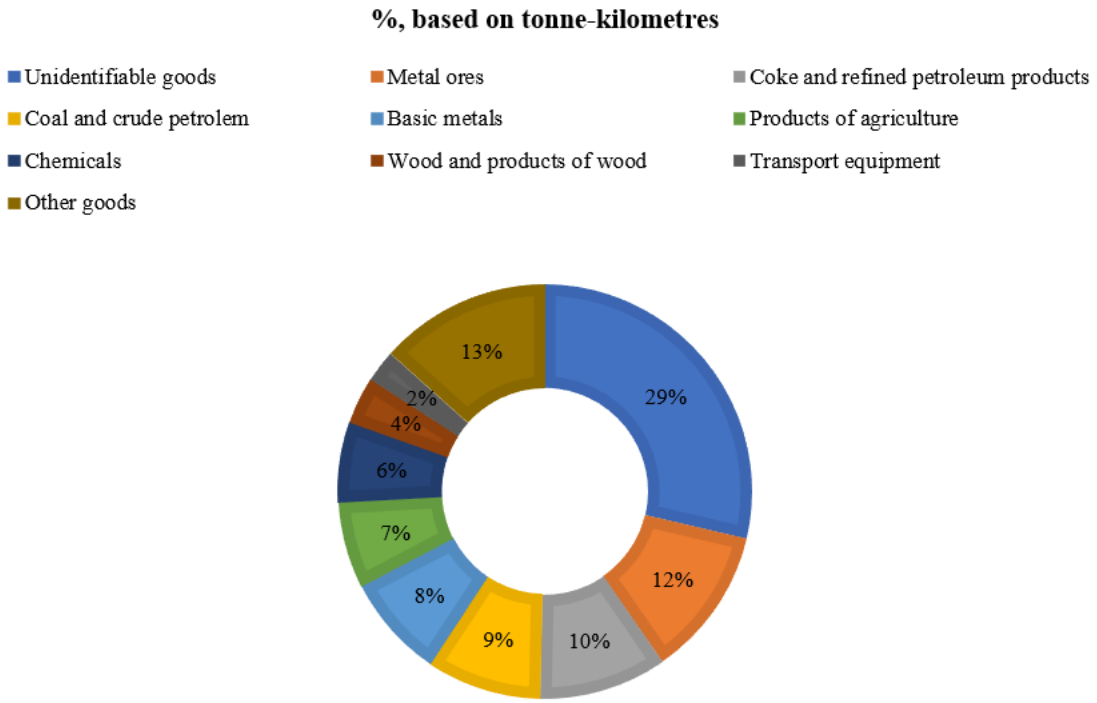

Figure 2.
Rail freight transport by type of goods for significant enterprises, EU
Source: Compiled based on [16].

The specifics of transport interaction in Europe largely depend on the regulatory framework governing international transport corridors between EU member states and their trading partners. The

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ISSN: 2576-8484
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European Union actively implements common standards in the *Trans-European Transport Network (TEN-T)* programme, ensuring harmonisation of transport operations. As of 2022, the TEN-T network covered more than 70,000 km of railways connecting the leading economic centres of Europe. EU regulations, such as Regulation (EU) No. 1315/2013, are aimed at creating standard rules for cross-border transport - technical standardisation, customs control procedures and environmental requirements. Particular attention is paid to multimodal systems, which combine rail, road and air transport to reduce the delivery time of goods.

China is actively developing international transport corridors, the largest of which is the One Belt, One Road, integrating railway routes with Europe. By the end of 2023, freight turnover between China and the EU increased by 23%, underscoring the importance of cooperation for international trade. China remains the leader in air cargo traffic, competing with the US regarding perishable goods and high-tech products. China's air cargo sector grew by 15% in 2022, driven by airport upgrades and the introduction of new cargo aircraft. The main programmes that form the basis of international transport corridors are shown in Table 1.

Table 1.
International corridor programmes in key regions of the world.

Country	Programme	Objective
China	The Belt and Road Initiative (BRI)	Increased geopolitical influence of China through control over key transport routes connecting Europe and Asia.
European Union	Investment Plan for Europe (EFSI)	Increasing the EU's competitiveness on the global stage by creating an integrated transport network.
Kazakhstan	Nurly Zhol programme	Positioning Kazakhstan as a key transit hub between China and Europe, strengthening its strategic influence in Central Asia.
Germany	National Railway Infrastructure Development Programme	Strengthening Germany's role as a logistics hub in Europe, particularly for transport between Western Europe and Asia.
Poland	Transport Infrastructure Development Programme for 2020-2030	Enhancing Poland's role as a transit country between Western Europe and East Asia through integration into European transport corridors.
India	Project of railway corridors for the accelerated development of freight transport	Strengthening India's position as a critical link in regional and international transport corridors, particularly with China and other Asian countries.
USA	National programme for the modernisation of transport infrastructure	Maintaining a leading position in the global market through control of significant transport arteries and development of infrastructure for global competitiveness.

Forming a transport and logistics system in urban cities is a complex process, as it requires the integration of different modes of transport to ensure the stability of transportation both within and outside the city. The main elements of the logistics system are rail, road, water and air transport, which together form a single multimodal transport network. Multimodal transport combines four modes of transport to deliver goods, which significantly helps optimise logistics costs. For example, in the major European cities of Rotterdam and Hamburg, the use of multimodal solutions has reduced the delivery time of goods by 20% and logistics costs by 15%. This was due to convenient connections between rail, road and sea routes. Automation systems for traffic flow management allow traffic intensity to be regulated to maximise the utilisation of transport hubs. As a result, improved urban transport efficiency reduces CO_2 emissions by 25% compared to traditional logistics approaches.

An analysis of transport projects shows high competition between regions in developing international railway corridors. The New Silk Road project competes with the European Union's leadership programmes for transporting goods between Europe and Asia. By 2030, it is planned to complete the construction of critical European corridors, which will increase capacity by 30%. China is investing heavily in upgrading its transport lines in Central Asia, increasing competition for control over traffic flows. According to the International Union of Railways (UIC), the volume of freight traffic through multimodal corridors could grow by 40% by 2030. This will create new opportunities for

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ISSN: 2576-8484
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international trade and strengthen economic ties between countries. The prominent companies leading in international freight transport are shown in Figure 3.

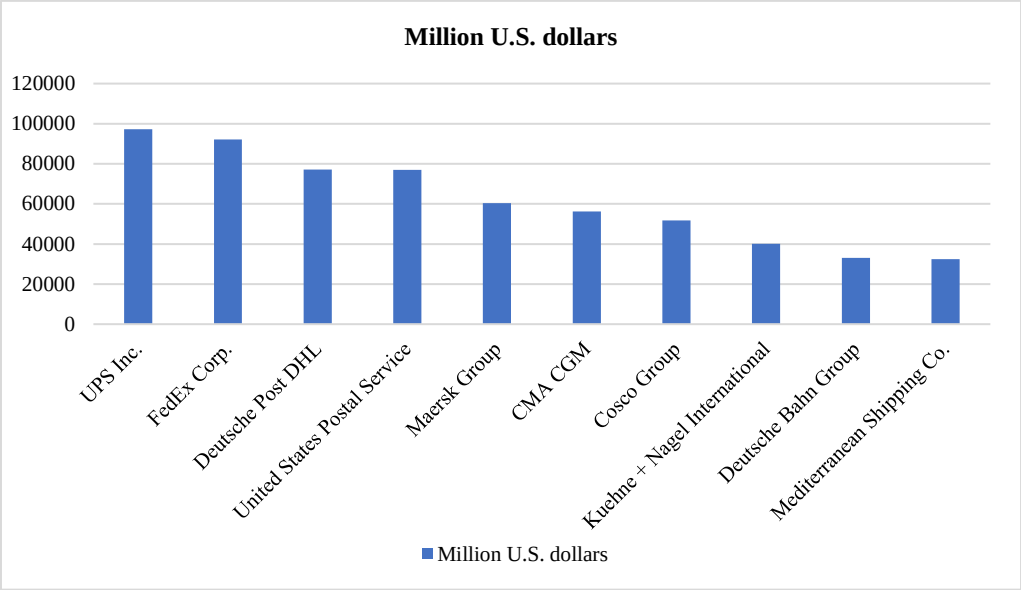

Figure 3.
Leading freight transport companies worldwide in 2022, based on freight revenue (in million U.S. dollars)
Source: Compiled based on [17].

Multinational corporations have a significant impact on the functioning of international transport corridors through strategic interactions with governments. Companies with the largest capitalisation, such as UPS Inc. and FedEx Corp. & are actively cooperating with the governments of the US, EU and Asian countries to improve transit routes. It is important to note that FedEx is involved in aviation infrastructure development projects in Southeast Asia, where the growing demand for electronics and technology goods requires high-speed transportation. Deutsche Post DHL is involved in developing railway corridors between Europe and China as part of the One Belt, One Road initiative. This will increase the volume of energy and raw materials, such as metals and oil, by 12% in 2022.

Cooperation between European countries and China on logistics initiatives is critical in ensuring the stability of the supply of strategic resources. For example, Maersk Group and CMA CGM are actively working to integrate maritime and rail transport systems, which can reduce containerised cargo transportation time by 15%. Interest in oil and natural gas transportation through multimodal transport corridors is growing, which is especially important for EU countries trying to reduce their dependence on Russian energy resources. In 2023, COSCO Group increased its raw materials transportation by 9% due to the expansion of cooperation with Central Asian countries, which was made possible by government support for transport projects and significant investments in infrastructure modernisation.

5. Discussion

Our results on developing international freight rail corridors confirm the economic importance of infrastructure modernisation. Our findings align with Cvahte Ojsteršek, et al. [18] who argues that integrating digital technologies into transport and logistics systems is critical to improving the efficiency of corridors. Similarly to Guo, et al. [19] our study shows that China and the EU are leaders in adopting multimodal solutions. Comparison with Ilin, et al. [20] shows that infrastructure projects in Kazakhstan and India require additional investment to reach parity with Euro5pean corridors. Ohiienko, et al. [21] findings on the impact of government policy on the development of railway networks

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 2: 374-383, 2025
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confirm our findings on the importance of public-private partnerships for financing large projects. The results correlate with the study by Saïah, et al. [22], which emphasises that the development of US rail corridors is heavily dependent on innovative traffic management technologies. The study has common theses with the findings of Fomin, et al. [23] who argues that cooperation between public authorities and the private sector is crucial for the sustainable development of railway corridors. Markarov and Davtyan [24] notes that European digital innovations aim to increase transportation speed. Our results confirm the thesis that regulatory changes are needed to reduce barriers to international freight transport, according to Prakash, et al. [25]. Vullapu, et al. [26] analysis indicates that the use of innovative technologies is an essential factor in strengthening the position of railway companies. We agree with the findings of Zhumanov, et al. [27] who notes that the role of private companies in designing railway corridor infrastructure is growing, while the role of the public sector is in the form of a lender.

6. Conclusions

Thus, developing international freight rail corridors is critical to ensuring an efficient transport and logistics infrastructure. This infrastructure stimulates international trade and regional economic integration after the decline during the COVID-19 pandemic. The strategic policies of China, the EU, Kazakhstan, India, the US, and Germany have shown that they place significant emphasis on modernising their railway networks by increasing investment in infrastructure projects. It has been found that the most effective strategies combine government initiatives with private capital. It allows for increasing corridors' capacity and reducing logistics services' costs. The article notes that the absence of common international transport and logistics regulation standards creates additional difficulties in harmonising transit flows between countries due to protectionism.

The development of digital technologies and the integration of multimodal systems are opening up new opportunities for improving railway corridors, but they also bring new challenges. Digitalisation allows for automating transport process management, but its implementation requires significant financial investments and adaptation to new operating conditions. For most multinationals, it is becoming clear that to ensure the sustainable development of railway corridors, it is necessary to intensify international coordination on standardisation and innovation by 2030. The largest railway companies, Deutsche Bahn and China Railway, play a leading role in shaping the future infrastructure. Their ability to adapt to new conditions will be crucial to ensuring the global competitiveness of the railway network.

Funding:
This study received no specific financial support.

Institutional Review Board Statement:
Not applicable.

Transparency:
The authors confirm that the manuscript is an honest, accurate and transparent account of the study that no vital features of the study have been omittedand that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Competing Interests:
The authors declare that they have no competing interests.

Authors' Contributions:

All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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