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Infrastructure development in Poland on railway freight routes between China and the European Union

Rozwój infrastruktury kolejowej w Polsce na szlakach towarowych między Chinami a Unią Europejską

Abstract

This paper evaluates infrastructural investments in Poland and their impact on rail transport development between China and the European Union. Using data from diverse sources, including EU databases and the PKP database, the study employs a comprehensive methodology to explore railway transport, identifying main freight routes, understanding determinants, and recognizing barriers and challenges. Emphasis is placed on dependencies in route exchange, the consequences of the Russia–Ukraine conflict, data analysis in connections between cities, corridors, and their current state, and trends, barriers, and new initiatives, including crucial structural developments in Poland. Findings reveal dynamic growth in container railway freight since 2013. Poland, exceeding most EU states in rail intermodal transport growth, appears poised to be an "intermodal logistics hub" with planned modernization. The paper offers practical significance, providing insights for policymakers, railway operators, and logistics providers, identifying opportunities and challenges for enhancing railway freight competitiveness between China and the EU and encouraging collaboration among BRI stakeholders to address shared issues. The originality of the paper lies in the assessment of the railway freight routes between China and the EU, the Belt and Road Initiative, and its relationship with the infrastructural investments in Poland.

Keywords:
Silk Road Economic Belt, Belt and Road Initiative, infrastructure development, rail infrastructure, China

Streszczenie

Artykuł ten analizuje inwestycje infrastrukturalne w Polsce i ich wpływ na rozwój transportu kolejowego między Chinami a Unią Europejską. W ramach opracowania korzystano z danych pochodzących z różnych źródeł, w tym z baz danych UE i bazy danych PKP. Do badania wykorzystano kompleksową metodykę w celu oceny transportu kolejowego, identyfikacji głównych tras towarowych, zrozumienia determinantów oraz rozpoznania barier i wyzwań. Nacisk został położony na zależności związane z modernizacją tras, konsekwencjami konfliktu między Rosją a Ukrainą, analizą danych dotyczących połączeń między miastami, korytarzami i ich aktualnym stanem, a także na trendy, bariery i nowe inicjatywy, w tym istotne strukturalne zmiany w Polsce. Wyniki obrazują dynamiczny wzrost w kolejowym transporcie kontenerowym od 2013 r. Polska, przewyższając większość państw UE pod względem wzrostu kolejowego transportu intermodalnego, wydaje się być „intermodalnym hubem logistycznym", rozwój którego determinowany będzie przez planowane dalsze modernizacje. Artykuł ma praktyczne znaczenie, dostarczając informacji dla decydentów, operatorów kolejowych i dostawców logistycznych, identyfikując możliwości i wyzwania związane z poprawą konkurencyjności przewozów kolejowych między Chinami a UE oraz zachęcając interesariuszy BRI do współpracy w celu rozwiązania wspólnych problemów. Oryginalność artykułu polega na ocenie tras przewozu kolejowego między Chinami a UE, Inicjatywy Pasa i Szlaku i jej związku z inwestycjami infrastrukturalnymi w Polsce.

Słowa kluczowe:
Pas Gospodarczy Jedwabnego Szlaku, Inicjatywa Pasa i Szlaku, rozwój infrastruktury, infrastruktura kolejowa, Chiny

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Introduction

China stands as a global leader in foreign trade, boasting significant figures in both exports and imports (Koopman, 2018, WTO, 2018). In particular, China holds the position of the largest partner for EU imports of goods and the second-largest partner for EU exports of goods. Notably, the European Union retains its status as the primary trading partner for China, accounting for 20% of its international economic exchange (Eurostat, 2018). Furthermore, the EU and China reciprocate as each other's principal source of imports. In 2016, China represented 20.2% of EU imports, surpassing the USA's 14.5%. Conversely, the EU constituted 13.1% of Chinese imports in the same year (García-Herrero (ed.), 2017). The trade competition between China and the USA have created a set of substantial implications that reverberate in the European Union thus being worth of study (Goulard, 2020).

To propel market integration and establish a comprehensive regional economic cooperation framework, the Belt and Road Initiative (BRI) was conceptualised in 2013. This initiative, also known as One Belt – One Road (OBOR), aims to revive ancient commercial routes connecting China to European nations through South-East Asia, Central Asia, and the Middle East. It encompasses the Silk Road Economic Belt and 21st Century Maritime Silk Road. Of particular significance within the Belt and Road is the rail route within the European Union, serving as a linchpin for trade between China and the EU.

In 2015, the pivotal Memorandum of Understanding on the EU-China Connectivity Platform was devised to enhance synergies between China's "One Belt One Road" initiative and the EU's connectivity initiatives, such as the Trans-European Transport Network policy (European Parliament, 2018a). Additionally, the European Parliament conducted a comprehensive study on the Belt and Road (European Parliament, 2018b), shedding light on the project's benefits and challenges for the EU, although an official cooperation strategy is yet to be established. Nevertheless, the initiative is widely recognized as a monumental development strategy with the overarching goal of fostering economic cooperation among nations along the proposed Belt and Road routes.

The Belt and Road envisions leveraging international transport routes, core cities, and key ports to establish six international economic cooperation corridors. These corridors will facilitate connections between China, the EU, and Southeast Asian countries. This endeavour necessitates extensive efforts in constructing and modernising various forms of transportation, including land, sea, and airports, alongside the establishment of critical transmission and telecommunications infrastructure within economic zones. Such initiatives are poised to stimulate economic development not only within Chinese provinces but also in neighbouring nations.

The significant surge in traffic along these routes owes much to subsidies provided by the Chinese government. These subsidies, sourced from the budgets of Chinese provinces, take various forms, including support for road transports delivering goods to loading points and direct subsidies for rail carriers.

By the end of 2017, co-financing for regular, compact rail container transport between China and Europe accounted for approximately 40–50% of total costs, which, in most cases, amounted to 4.0–4.5 thousand USD per TEU shipped (Putzger, 2017). However, it is noteworthy that the Chinese government is increasingly inclined toward the view that long-term development of connections with Europe should be grounded in market mechanisms, with subsidies gradually phased out. According to industry sources, transition was anticipated to occur around 2020–2022 (Jakóbowski et al., 2018, p. 27). Nonetheless, the support provided by the Chinese government has proven foundational to the development of railway freight. Similarly, the EU has introduced a number of directives of considerable importance, including:

1. Directive 2012/34, establishing a single railway area, as adopted by the European Parliament and the Council.
2. Commission Regulation (EU) No 1300/2014 of 18 November 2014, which lays down technical specifications for interoperability related to accessibility of the Union's rail system for persons with disabilities and persons with reduced mobility.
3. The White Paper entitled "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system," dated 23 March 2011.

From the perspective of the European Union, three principal Eurasian transport corridors emerge (Hillman, 2018):

1. The Northern corridor, starting in eastern provinces of China, proceeds through Russia via Mongolia (Chinese Middle Bound Corridor) or directly (Chinese Eastbound Corridor). It then follows the Trans-Siberian Road toward Europe, with the Middle and East Bounds Corridors connecting to Transbaikal.
2. The Middle corridor connects, primarily, central and western provinces of China with Europe through a railway route traversing Kazakhstan and Russia.
3. The Southern corridor originates in Central Europe and links western provinces of China with countries in Central Asia and Central Europe.

Of these, the entrances to the branches of the Northern and Middle Corridors hold paramount importance for the European Union. Currently, the largest "gateway to the European Union" lies at the Polish-Belarusian railway border crossing in Terespol (Małaszewicze)–Brest.

The ongoing conflict between Russia and Ukraine has reverberated through global geopolitics and economic networks, with serious consequences for initiatives like the Belt and Road Initiative (BRI). The war has disrupted critical transport and energy routes, giving rise to a new geopolitical landscape characterized by sanctions and diplomatic tensions. This has cast doubt on the viability of the Eurasian land bridge, a fundamental overland corridor linking China and Europe through Russia (Mendez et al., 2022).

According to Prebilič and Jereb (2022), the war in Ukraine and the isolation of Russia have raised doubts about the success of the BRI and its mainland corridor, known as the Eurasian land bridge. The Middle corridor has gained significance as a short-term alternative trade route, primarily because of its proximity to the Eurasian land bridge. This route extends from China, traverses Central Asia, crosses the Caspian Sea, passes through the Caucasus, Turkey, and ultimately reaches Europe (Prebilič & Jereb, 2022; Mendez et al., 2022).

The fallout from the conflict has prompted China to reassess its strategies, particularly in terms of diversifying energy sources and exploring alternative markets. Notably, there has been a surge in imports from regions such as Saudi Arabia, and substantial investments have been directed towards energy ventures in Central Asia and Iran. Furthermore, the conflict has strained the China–Russia alliance, as China navigates concerns over potential sanctions and reputational damage, while Russia seeks economic and political support. As a result, this evolving geopolitical landscape is prompting a re-evaluation of the BRI's trajectory and the exploration of alternative routes and partnerships to safeguard its strategic objectives in a changing global context (Prebilič & Jereb 2022; Mendez et al., 2022; Gürel & Kozluca, 2022).

Poland, as a partner in the OBOR initiative, has also introduced significant regulations in the railway sector. In 2015, Poland signed a Memorandum of Understanding (MoU) with China, consolidating their cooperation in the Belt and Road project. Moreover, in 2017, Poland declared support for the public sector to enhance the utilisation of railway freight potential in international transport, particularly in intercontinental routes (Silk Road) as outlined in the Strategy for Responsible Development by 2020 (with a perspective by 2030) (Ministry of Development, 2017). This inclusion of actions for the initiative in strategic documents underscores Poland's commitment.

As of 20 April 2017, a multilateral Agreement for Further Cooperation on China-Europe Container Block Trains Among Railways of China, Belarus, Germany, Kazakhstan, Mongolia, Poland, and Russia has come into effect (Agreement…, 2017). This agreement has facilitated intensive cooperation to implement legal, operational, and technical enhancements aimed at bolstering the efficiency of railway freight transport for goods exchange between China and the European Union. The agreement has established joint working groups to address overarching problem areas and expert working groups to provide recommendations for improving container rail links between China and the EU.

Poland's policy approach has been guided by the Transport Development Strategy by 2020 (with a perspective by 2030), the Master Plan for railway freight in Poland by 2030, and the National Railway Programme by 2023 (Ministry of Infrastructure, 2015). These strategic documents outline the main lines of action and contribute to the creation of a stable and predictable national railway policy, reinforcing the nation's role as a partner in the OBOR initiative.

The National Railway Programme, a multiannual program encompassing investments in railway lines, aligns with the objectives defined in the Strategy for Responsible Development. The program underwent revision in November 2016 to enhance the implementation and disbursement of allocated funds. The overarching goal remains to strengthen the position of railway transport in the country's integrated transport system, establishing a cohesive and modern network of railway lines.

The existing literature lacks comprehensive studies that specifically delve into the infrastructural investments made in Poland and their consequential influence on the development of rail transport between China and the European Union (Z. Chen & Li, 2021; Komornicki & Goliszek, 2023; Rokicki et al., 2021). While various programs and agreements facilitate investments and cooperation in railway routes among nations, the ongoing conflict between Russia and Ukraine emerges as a disruptive event (Chen, 2022; Doński-Lesiuk, 2022; Eldem, 2022; Pomfret, 2023). This conflict is crucial to consider, due to its potential implications for railway freight routes.

After joining the European Union, Poland has emerged as a significant beneficiary of structural funds aimed at mitigating development differences between regions. Particularly substantial expenditures were allocated for the enhancement of underinvested transport infrastructure (Kopiec et al., 2019). Due to its strategic geographical location, Poland boasts convenient road, rail, and air connections with the capitals of European Union countries and is well-positioned for trade with

nations neighbouring the EU to the East (Kopiec et al., 2019; Wengel & Galla, 2021). Furthermore, over the past decade, the Polish Government and the European Union have invested in projects to modernize the current railway infrastructure, with expected improvements by 2030 (Kruszyński & Waniewska, 2018).

The main objective of this paper is to assess infrastructural investments in Poland and their impact on the development of rail transport between China and the European Union. The article delves into the primary rail freight routes connecting China and the EU, exploring the determinants driving their development. It underscores the burgeoning growth of intermodal transport in Poland, attesting to the nation's strategic location and high logistical value. Additionally, it scrutinises Poland's current and prospective significance as an "international logistic hub." The paper also sheds light on the role of PKP Group companies in the freight of the Belt and Road Initiative, outlining their plans for the development of the China–Poland–European Union rail freight axis. Data utilized in this research is sourced from EU databases and the PKP database, with the paper employing a synthesis of available sources and inductive reasoning in its analysis.

Materials and methods

This study is based on a comprehensive synthesis of data from various sources, including the European Union (EU) databases, the PKP database, and the archive preprint server. The methodology adopted in this study involves an in-depth analysis of the railway type of transport. This includes identifying the main rail freight routes, understanding their development determinants, and recognizing their barriers and challenges (Andrzejczak, 2023). A significant part of this research is dedicated to understanding the role of the PKP Group companies in freight on the Belt and Road. This involves studying their plans for the development of the China–Poland–EU rail freight axis.

In this study, we have placed special emphasis on the following aspects, in this order:

1. Search for dependencies in the exchange of routes between Europe and China.
2. Analytical impression of the consequences of the war between Russia and Ukraine.
3. Analysis of data, especially in connections between cities, corridors, and their current state, speed, terminals, and train widths variants.
4. Search for trends, barriers, new initiatives, and analysis of crucial structure development in Poland.

To examine the reaction of the freight transport market to changes in traffic parameters introduced in the network, this study employs the Railway Traffic Model. This model allows for a detailed analysis of how changes in traffic parameters can affect various aspects of freight transport. In addition to this, several key metrics are used to evaluate the economic rentability of investment projects. These include time savings, cost savings, environmental impact, and transport safety. Each of these metrics provides valuable insights into different aspects of economic rentability.

Results

Railway potential within the Belt and Road Initiative

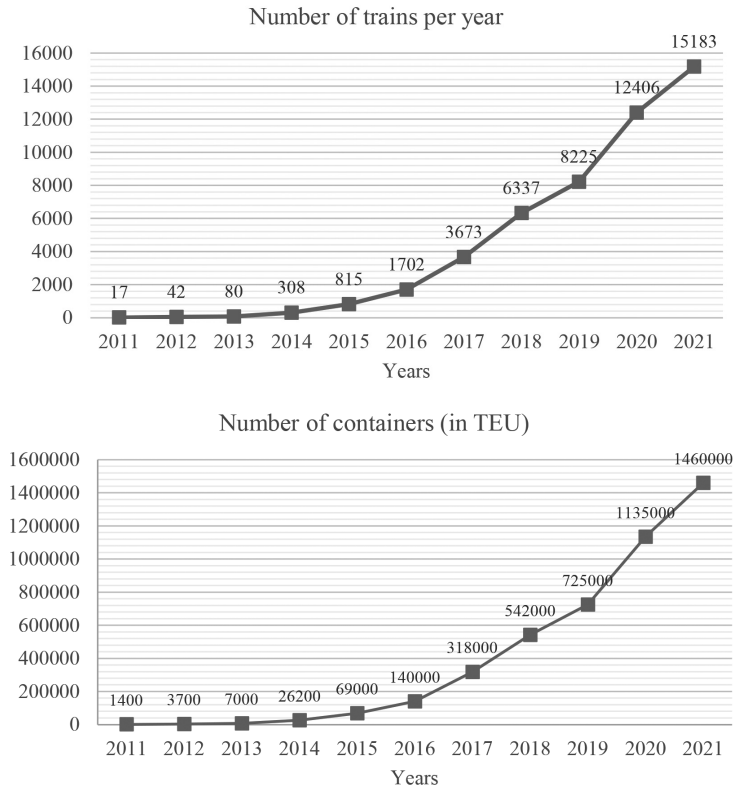
China considered that, within the BRI framework, railway freight should ultimately have the second most significant share, after sea freight, in the transport of goods between China and Europe, accounting for about 10%, because in case of serious disruption on the main maritime route connecting China and Europe, large volumes of goods could only be transported by rail. In 2017, the railways transported approximately 200,000 of the total of 10 million TEU in freight between China and the European Union; these shipments corresponded to 4% of the value of trade in goods with China. In addition, 118,000 TEU were shipped between China and other countries, i.e. (Vinokurov et al., 2018) Russia, Belarus, Turkey, Vietnam, Afghanistan, and Iran. This translated into 2,399 trains per year that arrived from China to Europe.

At the end of 2017, all the major provinces of China either dispatched their own trains to Europe or had ambitions to do so. In every province where railway container depots are regularly formed to set off for Europe, there are transshipment terminals which are among the largest in the world. The detailed information about the total exchanges between Europe and China can be found in Figure 1.

One of the transport corridors between China and Europe is the Southern Corridor, bypassing Russia by the railway route to Turkey. Countries involved in infrastructure development currently assume that container trade between China and Turkey (including transit) would be up to 300,000 TEU per year by 2020 (Jakóbowski et al., p. 56).

An alternative to the Southern Corridor is the Trans-Caspian International Transport Corridor (TITR), also known as the south part of the Middle Corridor. However, the transport of goods in this case is much more complicated and more expensive

Figure 1
Number of trains and containers between China and Europe (2011–2021)



Source: data 2011–2017: China Railway Container Transport Co. Ltd.; Vinokurov et al., 2018, p. 41; Siqi, 2022; Statista, 2021.

compared to the Trans-Siberian Corridors. TITR is a branch of the Chinese Western Route. It leads through Kazakhstan to the ports of Aktau and Kuryk, then via the Caspian Sea to Azerbaijani Baku, then by Batumi railway to the ports of the Black Sea (Ukrainian Chornomorsk, Romanian Constanţa or Istanbul), and crosses the borders of the European Union in Hrubieszów (entering Poland via the broad-gauge line) or Bulgaria (connecting with the land part of the Southern Corridor) or in Romania.

Within this corridor to the European Union, a stream of goods could flow through the Slovak Košice or the Polish-Ukrainian Hrubieszów–Izov border crossing, from where the westernmost broad-gauge railway line of PKP LHS could be used to reach the Sławków Euroterminal, located not far from the RFC 5 Baltic–Adriatic.

Railway volume within the Belt and Road Initiative

According to PKP LHS estimates, based on minutes from the General Assembly of TITR members from this year (data from PKP LHS, 2019), it is assumed that 60,000 TEU will be transported annually in transit along this corridor. On the other hand, the LHS forecasts for freight made via the TITR corridor and the south–west route, measured by the number of inquiries and potential contracts already at an advanced stage, are respectively: 20,000 TEU for the south–west route (from Azerbaijan) and 5,000 TEU via the Trans-Caspian Corridor directly from China. According to PKP Cargo data for 2018, container trains from China to the European Union currently cross the Polish eastern border through the main railway crossings (Table 1).

The goal is to increase transport through the remaining available PKP border crossing points, adapted to container transport (listed in Table 1). In addition, a border crossing point between Czeremcha and Vysokolitovsk, 45 km north of Terespol, is to be launched, which should relieve some of the burden on the largest border crossing point on the EU's eastern border.

As for 2019, alternative transit routes include routes through Slovakia (transshipments between 1,520 mm and 1,435 mm gauge tracks at the terminal in Dobra near Košice), Lithuania (transshipments between 1,520 mm and 1,435 mm gauge tracks at terminals in Kaunas or in Shostakhov or transshipments between 1,520 mm track and sea way in Klaipeda), Kaliningrad Oblast

(with transshipments at terminals in Koenigsberg between 1,520 mm and 1,435 mm tracks or between 1,520 mm track and seaway (mainly to/from German Rostock), or via St. Petersburg or Ust-Luga port directly to EU Baltic Sea ports. Despite the possibility of using the above-mentioned routes, as much as 90% of the rail freight sent in 2018 by land between China and the European Union still passed through the Brest (BC)–Terespol (PKP) border crossing and was served in the border "dry transshipment port" Małaszewicze.

The conflict between Russia and Ukraine has had profound consequences for the Belt and Road Initiative (BRI) (Prebilič & Jereb, 2022). It has disrupted crucial transport and energy routes of the BRI, establishing a new 'Iron Curtain' of sanctions against Russia and its allies. This has led to re-evaluation of the viability of the Eurasian land bridge, a pivotal overland corridor connecting China and Europe via Russia. In the present context, the ramifications of the Ukraine–Russia war on the BRI are as follows (Mendez et al., 2022):

1. China faces heightened difficulty in financing infrastructure projects along the BRI, particularly in Russia and Belarus. These countries are integral to the New Eurasian Land Bridge (NELB) corridor.
2. Some European nations have become less inclined to collaborate with China and other BRI nations that are perceived as supportive of Russia. Notably, this sentiment is prominent in countries like Kazakhstan and Moldova.
3. The geopolitical competition between China and the United States has intensified. Both nations perceive the BRI as a strategic instrument for extending influence and challenging the prevailing US-led international order.
4. Global supply chains and trade flows within the BRI have been disrupted, especially in sectors like the automotive industry, which heavily relies on rail transport between China and Europe via the NELB corridor.
5. The war has exacerbated worldwide food and energy crises, influencing China's own food and energy security. This, in turn, impacts China's capacity to provide assistance to other BRI participant countries.

Despite the possibility of using the alternative routes, still over 90% of the rail freight sent in 2018 by land between China and the European Union passed through the Brest (BC)–Terespol (PKP) border crossing and was served in the "dry transshipment port" Małaszewicze. Also, UIC experts (Berger, 2017) predict that in 2027 Brest/Małaszewicze will remain the main entry point to the European Union with an estimated share of more than 50%. However, border-crossing terminals are in need of expansion in order to avoid becoming a bottleneck of Eurasian rail freight. Therefore, Poland has started intensive efforts to improve the quality of railway infrastructure, both of linear and nodal type, and to increase the attractiveness of rail freight for freight operators in EU–Asia relations and to maintain the highest competitiveness of connections passing through it in transit, which is discussed in this article.

In Poland, most of the intermodal transport by rail is also carried out by direct sea freight transport (from and to the Polish ports of Gdańsk, Gdynia, and Szczecin-Świnoujście), but there is a steady increase in the number of containers and the weight of cargo transported by land along the Belt and Road route between China and the European Union.

Statistics and forecasts of railway traffic on the Belt and Road indicate a steady growth of the container stream in the years to come. Official Chinese Government portal (China Belt and Road Network, 2019) declares a 72% y/y increase in the number of containers transported on the Belt and Road in 2018 (up to 6,300 trains in total to/from China).

Bearing in mind the announcements of the Chinese side, and looking at the percentage annual growth, PKP Cargo confirms that the cargo flow from China to the European Union is growing by about 20–25% per year and this trend should continue (Directorate-General for Trade, 2023; Eurostat, 2023).

Predicting the impact of the development of the Belt and Road concept on the transport network poses difficulty due to the enormous capacity of the concept and the constant evolution of its scope. Moreover, it is not possible to distinguish trade generated specifically by the BRI initiative itself from trade in the broader sense between China and Europe. The investments attributed to the initiative represent only a small part of the total investment, which could in any case be carried out by owners and managers of air, sea, rail and road infrastructure throughout Eurasia. However, the study (European Parliament, 2018b) showed that, as a result of improved railway freight services, by 2040, around 2.5 million TEU of freight could be shifted from maritime transport and 0.5 million TEU from air transport to rail. This corresponds to 50–60 additional trains per day on the Europe–China route in each direction (European Parliament, 2018b).

Barriers for the initiative's development

China has identified the following main operational barriers on the Polish section of the Silk Road (Song, 2016; HKTDC, 2018):

- limited throughput of border crossings and terminals, especially in the Małaszewicze region,
- lack of availability of locomotives and platform wagons for transporting containers,

- insufficient productivity of information exchange,
- too lengthy customs procedures.

Other reasons, not mentioned above, for the disruption of freight logistics processes in China and the European Union, also include the following:

- insufficient throughput of the linear infrastructure in Poland (transit routes, delivery lanes in reloading areas),
- too few and inadequate quality of logistical infrastructure facilities used to handle container freight by rail at and near border crossings, within the area of contact of 1,435 mm and 1,520 mm gauge rails, including, in particular transshipment terminals, phytosanitary control points and customs offices, which strongly slows down the entry of containers into the EU.

Polish railway companies undertook a number of initiatives, addressing their expectations in the form of investments in linear and modal infrastructure.

Crucial infrastructure development in Poland

The legal framework influences the current shape of Poland's transport policy and the main legal acts determining the current infrastructure investments. Based on strategic EU documents and guidelines of the Polish government, the companies of the PKP Group undertook a number of actions aimed at improving the quality of railway infrastructure operation.

Given the particular importance of the Polish infrastructure for rail freight between China and the EU, the Polish authorities, with the support of the EU, carried out extensive measures to modernize the existing linear and nodal infrastructure between 2007 and 2015.

The financing of investment projects approved in the Strategy for Responsible Development is to be provided primarily by the EU budget from the Operational Programme Infrastructure and Environment in the amount of EUR 12.172 billion dedicated to the modernization of, among others, railway lines (Resolution No. 173/2017 of the Council of Ministers, 2017). Between 2007 and 2015, the quality of rail transport infrastructure in Poland improved substantially. The proportion of lines in good technical condition increased from 25% to 55%, while the share of lines in unsatisfactory technical condition shrank from 28% to 16%. The large-scale modernization and revitalization projects, implemented with support from EU funds, have increased the attractiveness of rail in Poland (Wołek, 2018, p. 8).

Poland has not only established better transport connections with neighbouring countries of the European Union but has also prepared a plan of coordinated actions in form of National Railway Programme until 2023 (NRP), which was adopted via a resolution of the Council of Ministers from 15 September 2015 (updated in November 2016) to provide a gateway to the European Union.

For the purpose of this paper, a list of investment projects influencing the current freight corridors and the development of railway freight on the Belt and Road has been created.

Infrastructure investments were divided into three areas:

- modernization of railway lines;
- modernization of railway infrastructure near railway border crossings at the junction of 1,520 mm and 1,435 mm gauge tracks;
- modernization and construction of new intermodal terminals and logistics centres.

The list shows how the planned investments are fitting into the existing linear and nodal infrastructure from the perspective of increasing the throughput capacity of the railway network and intermodal transshipment terminals for the benefit of intermodal freight.

Table 1 shows the current state of linear infrastructure of key importance for intermodal transport. Highlighted there are key railway sections in the context of the pan-European corridors and the TEN-T network, with maximum authorized speeds for freight trains and the maximum authorized length of trains, identifying also the most important areas for potential upgrades (Table 1). The planned and pending investments in linear infrastructure affecting the rail freight to/from China were indicated, with the effect of maximum speed at that section being 120 km/h and minimum length of station tracks 740 m:

1. Section Sochaczew–Swarzędz.
2. Control-Command Section (LCS) Terespol.
3. Works on C-E 65 line on the Maksymilianowo–Chorzów section.
4. Works on the E 65 railway line on section Będzin––Katowice–Tychy–Czechowice Dziedzice–Zebrzydowice.
5. Works on the line no. 353 on the section Jabłonowo Pomorskie–Iława–Olsztyn–Korsze.
6. Works on the E 65 railway line at section Łódź Kaliska–Zduńska Wola–Ostrów Wielkopolski.
7. Works on section Sadowne–Czyżew.

After the completion of the above-mentioned projects, it is expected that the quality of transport will be improved, inter alia, by increasing the average speed of trains, increasing the throughput capacity of railway lines, as well as increasing the safety of railway transport operations. The key condition to long-term significant increase in the attractiveness of container railway freight through Poland is the creation of a network of high-quality

generally available terminals allowing for fast and reliable inter-branch handling. These facilities should be available throughout Poland rather than just only in few regions, as is currently the case (at present there are 36 terminals in Poland adapted to the needs of container handling).

As regards modernization and construction of new intermodal terminals and logistics centres, four investments are currently being implemented and planned. These are presented in Table 1, showing the current state of nodal infrastructure of key importance for intermodal transport along the Belt and Road. This action is also part of the initiative to create in Poland a logistics platform serving the markets of Central and Eastern Europe, which would be able to handle the increasing flows of cargo transported (not only by rail) between China and Europe.

Solidarity Transport Hub Poland (STH) is the concept of a high-capacity logistics centre with good road and rail access. STH will include railway investments: railway nod in close vicinity of an airport, as well as connections within Poland enabling transfer between Warsaw and the largest Polish cities in less than 2.5 hours. A natural advantage of STH, apart from its central location in Poland and good access to motorways, would be the possibility of combining on the first and last miles of cargo transported by different modes of transport between distant locations, considering the main transport corridors.

The application of the mechanism would allow for a significant acceleration of transport across Poland's eastern border and would also increase the reloading capacity of the largest transshipment terminals located at the junction of railway lines with different rail gauge. Reducing transport time would make railway freight more competitive in relation to maritime transport on routes between China and the EU, as well as reducing damage and theft losses.

In addition, PKP Group companies have taken several initiatives aimed at removing transport barriers, which had been highlighted by the Chinese side (Song, 2016). To eliminate the risk of lack of container transport platforms, PKP Cargo announced, on 4 September 2018, a tender for the purchase of 936 intermodal platforms; at the end of the year the company also received EU funding for the purchase of another 220 container transport platforms dedicated to international transport. In total, in the years 2018–2023, PKP Cargo planned to purchase over 1000 wagons-platforms, which will improve the transport process and ensure greater reliability of operation.

PKP Cargo has also taken important measures to address the issue of insufficient productivity of information exchange. Mechanisms are being developed for providing information on wagons and containers on trains travelling from China to Europe before their physical arrival at the border crossing points, as well as railway and customs documentation necessary to cross the external customs border of the European Union. This optimizes the use of resources and speeds up rail and customs formalities, which has a significant impact on the total time it takes for containers to be transported by rail from China to EU countries. Currently, efforts are being made to obtain the necessary data after the transshipment of trains at border crossings in China (1,435 mm) to 1,520 mm railways (Kazakhstan, Mongolia, Russia), which would give at least a few days of reserve to prepare for the acceptance of the train to the network in Poland, customs and border clearance of shipments, transshipment of containers, and the formation of trains for their final transport to terminals of destination on the European rail network (Table 2).

The implementation of the traffic management and control coordination mechanism of Tory-24 (Tracks-24) makes it possible to improve the handling of trade in goods through:

- faster electronic exchange of information;
- availability of information for users operating in different locations;
- coordinating the place and time of the inspection of goods;
- possibility of monitoring the process of handling the trade of goods.

The carrier/forwarder/customs agency/postal operator is given the opportunity to directly participate in the freight handling process from the moment of entry of the train, submission of the request for an inspection to the relevant service/inspectorate, transmission, or acquisition of information on the time and place of inspection and its results. The services will receive advance information (advice) about the intention to apply for control by the dispatcher of the goods, which allows for effective work planning and enables the exchange of additional information between users at each stage of the control process.

Companies from the PKP Group work on the development of technologies and innovative solutions to support intermodal transport. One of possible actions to streamline the movement of loads across the Polish eastern border is also to implement, on a wider scale, a system for automatic gauge changing (with the second generation of the SUW-2000 system seeming to be the most promising), which would allow reloading-free movement of railway consignments through the 1,435 mm and 1,520 mm gauge intersections.

However, it would take several years from verification of a greater long-term interest in using such a solution until the time of its potential commercial implementation. This includes a time needed to refine the configuration of the implemented

Table 1

Linear infrastructure of key importance for intermodal transport – maximum authorised speed, maximum authorised length and intermodal transport (railway track 1,435 mm).

Origin	Destination	Border crossing	Pan-European transport corridors	Modernization areas within corridors	Maximum train speed [km/h]	Maximum train length [m]	Intermodal terminals
Białystok	Warszawa	Kuźnica-Grodno	Main	Main, investment areas	60–90, 100–110	600–690, 750–800	Planned and key investment (Białystok), inland (Warszawa)
Białystok	Olsztyn	Skandawa–Żeleznodorożnyj (nearest to Białystok), Kuźnica–Grodno (nearest to Olsztyn)	Main (Białystok)	Main, investment areas (Białystok), investment areas (Olsztyn)	60–90, 100–110	600–690	Planned (Białystok)
Olsztyn	Gdańsk	Kuźnica–Grodno (nearest to Olsztyn), Braniewo–Mamonowo (nearest to Gdańsk)	Main (Gdańsk)	Investment areas (Olsztyn)	60–90, 100–110, 120	600–690, 750–800	Seaside (Gdańsk)
Warszawa	Gdańsk	Kuźnica–Grodno (nearest to Warszawa), Braniewo–Mamonowo (nearest to Gdańsk)	Main (Gdańsk)	Investment areas (Olsztyn)	60–90, 100–110, 120	750–800	Inland (Warszawa), seaside (Gdańsk)
Olsztyn	Warszawa	Skandawa–Żeleznodorożnyj (nearest to Olsztyn), Kuźnica–Grodno (nearest to Warszawa)	Main (Warszawa)	Investment areas (Olsztyn)	60–90, 100–110, 120	600–690, 750–800	Inland (Warszawa)
Warszawa	Lublin	Kuźnica–Grodno (nearest to Warszawa), Dorohusk–Jagodzin (nearest to Lublin)	Main (Warszawa), Supplementary (Lublin)	None	60–90	600–690, 750–800	Inland (Warszawa and Lublin)
Warszawa	Łódź	Kuźnica–Grodno (nearest to Warszawa)	Main (Warszawa), Main (Łódź)	Investment areas (Łódź)	60–90, 100–110, 120	0–590, 750–800	Inland (Warszawa and Łódź)
Warszawa	Toruń	Kuźnica–Grodno (nearest to Warszawa)	Main (Warszawa), Main (Toruń)	Investment areas (Toruń)	60–90, 100–110, 120	600–690, 700–725, 750–800	Inland (Warszawa)
Warszawa	Bydgoszcz	Kuźnica–Grodno (nearest to Warszawa)	Main (Warszawa), Main (Bydgoszcz)	Investment areas (Bydgoszcz)	60–90, 100–110, 120	750–800	Inland (Warszawa), planned and key investment (Bydgoszcz)
Łódź	Bydgoszcz	None	Main (Łódź), Main (Bydgoszcz)	Investment areas (Łódź), investment areas (Bydgoszcz)	0–50, 60–90, 100–110	750–800	Inland and key investment nearby (Łódź), planned and key investment (Bydgoszcz)
Łódź	Toruń	None	Main (Łódź), Main (Toruń)	Investment areas (Łódź), investment areas (Toruń)	0–50, 60–90, 100–110	600–690, 700–725, 750–800	Inland and key investment nearby (Łódź)

Cont. Table 1

Origin	Destination	Border crossing	Pan-European transport corridors	Modernization areas within corridors	Maximum train speed [km/h]	Maximum train length [m]	Intermodal terminals
Łódź	Katowice	Slovakia, Austria (nearest to Katowice)	Main (Łódź), Main (Katowice)	Investment areas (Łódź), investment areas (Katowice)	0–50, 60–90, 100–110, 120	600–690, 750–800	Inland and key investment nearby (Łódź), inland (Katowice)
Łódź	Poznań	Germany, Belgium, Netherlands (nearest to Poznań)	Main (Łódź), Main (Poznań)	Investment areas (Łódź), investment areas (Poznań)	0–50, 60–90, 100–110	600–690, 700–725, 750–800	Inland and key investment nearby (Łódź), inland (Poznań)
Poznań	Gorzów Wielkopolski	Germany, Belgium, Netherlands (nearest to Poznań)	Main (Poznań)	None	60–90	600–690	Inland nearby (Gorzów Wielkopolski), inland (Poznań)
Poznań	Toruń	Germany, Belgium, Netherlands (nearest to Poznań)	Main (Poznań), main (Toruń)	Investment areas (Toruń)	0–50, 60–90, 100–110	600–690, 700–725, 750–800	Inland (Poznań)
Poznań	Bydgoszcz	Germany, Belgium, Netherlands (nearest to Poznań)	Main (Poznań), main (Bydgoszcz)	Investment areas (Bydgoszcz)	60–90, 100–110	600–690, 700–725, 750–800	Inland (Poznań), planned and key investment (Bydgoszcz)
Poznań	Wrocław	Germany, Belgium, Netherlands (nearest to Poznań); Czechia, Austria (nearest to Wrocław)	Main (Poznań), main (Wrocław)	None	0–50, 60–90, 100–110	600–690, 700–725, 750–800	Inland (Poznań), inland (Wrocław)
Szczecin	Gorzów Wielkopolski	Germany, Belgium, Netherlands (nearest to Szczecin), Czechia, Austria (nearest to Wrocław)	Supplementary (Szczecin)	None	60–90, 100–110	600–690	Seaside (Szczecin), inland nearby (Gorzów Wielkopolski)
Szczecin	Wrocław	Germany, Belgium, Netherlands (nearest to Szczecin); Czechia, Austria (nearest to Wrocław)	Supplementary (Szczecin), main (Wrocław)	None	0–50, 60–90, 100–110, 120	0–590, 600–690	Seaside (Szczecin), inland (Wrocław)
Wrocław	Opole	Czechia, Austria (nearest to Wrocław); Slovakia, Austria (Opole)	Supplementary (Szczecin); main (Opole)	None	0–50, 60–90, 100–110, 120	600–690, 700–725	Inland (Wrocław)
Katowice	Kraków	Slovakia, Austria (nearest to Katowice and Kraków)	Main (Katowice); main (Kraków)	Investment areas (Katowice)	0–50, 60–90, 120	0–590, 600–690	Inland (Katowice), inland (Kraków)
Kraków	Rzeszów	Slovakia, Austria (nearest to Katowice and Kraków); Medyka–Mostiska II	Main (Kraków); main (Rzeszów)	None	0–50, 60–90, 120	0–590, 600–690, 750–800	Inland (Kraków), container reloading point nearby (Rzeszów)

Source: own study based on data from PKP PLK, PKP Cargo and PKP LHS.

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Table 2
Variants of cargo movement at the contact point of different track gauge

Variant	Name	Method of operation	Operating time [min]	Calculation performance		Versatility
				weight/hour	tonnes/hour	
I	Cistern-cistern pumping	Overflow station	40	1,5	90	Required technological stock of wagons
II	Transshipment of cargo units	Transshipment berth	6	10	215	Full
III	Replacement of trolleys with body lift	Resetting station	20	3	180	Required technological stock of trolleys
IV	Automatic Gauge Changing Systems	Continuous, with the use of a resetting station	0.5	120	7200	Carriage in single wagons, in groups or full train

Source: own elaboration.

variant of the system, then test it, and to launch serial production of variable-track axle sets to be used in freight wagons, and to construct track gauge setting points at the interface between tracks of different gauges, through which it will be possible to change the track width automatically, without unloading or changing wagons or their bogies (Table 2).

Discussion on measurement of infrastructure investments on the railway routes of the Belt and Road

According to PKP PLK's declarations, the impact of investments carried out within the National Railway Program on intermodal transport along the railway Belt and Road is significant. By 2030, thanks to the modernization carried out, the maximum speeds for freight trains will be increased to 100 km/h and the permissible length of trains to 740 m for all lines modernized within the TEN-T network.

However, to confirm how this will affect the distribution of freight flows along railway lines in Poland, PKP, together with PKP PLK, plans a study using the Railway Traffic Model, which will present forecasts of crossing times and volumes for a given line after taking into account new (post-investment) parameters of railway lines. Railway Freight Model – the Traffic Model allows to examine the reaction of the freight transport market to changes in traffic parameters introduced in the network (Kaczorek et al., 2018). It is important for companies to be able to examine and demonstrate the impact of the investment on the functioning of the transport market on a national scale with the use of a tool based on a 3-step model (Kaczorek et al., 2018):

1. Loading onto vehicles – division of traffic into train sets, considering the used train length.
2. Distribution of traffic in the network.
3. Calculation of the volume of transported goods based on base traffic and differences in effective network parameters.

Each investment project should attain a given level of economic rentability. The following metrics should be included:

- time savings in freight traffic;
- savings from the freight vehicles exploitation;
- savings from reduced impact of vehicles on the environment;
- savings from increased transport safety stemming from transport modal change from road to railway;
- savings from reduced impact of freight transport on the climate change, owing to modal change from road to railway.

PKP and PKP PLK are planning to prepare an assessment of the impact of the infrastructure investments mentioned in this paper – using the National Railway Model – on the distribution of freight streams along the railway routes of the Belt and Road running through Poland.

Conclusions

Since 2013, there has been a dynamic development of container railway freight between China and the European Union. The railways transport share reached 2% of the total volume of trade in goods between China and the European Union, which translates into 4% of its value. The conflict in Ukraine and Russia's isolation has cast uncertainties on the viability of the Belt and Road Initiative (BRI) and the Eurasian land bridge. In response to these challenges, the Middle Corridor has emerged as a noteworthy short-term alternative for trade. Its significance is primarily attributed to its proximity to the Eurasian land bridge. This alternative route originates in China, traverses Central Asia, crosses the Caspian Sea, moves through the Caucasus and Turkey, ultimately connecting with Europe.

In the years 2010–2018 in Poland the annual growth rate of rail intermodal transport was over 15%, which was much higher than in most of the European Union Member States. Maintaining the high growth rate of rail intermodal transport volume after 2020 will not be possible unless significant investments are made in the development and modernization of logistics infrastructure supporting multimodal transport with the participation of railways.

The geographical structure of China–EU rail transit routes and the use of individual transport corridors depend not only on the state of political cooperation and consensus of all stakeholders along a given route, but also on the active involvement of numerous state institutions. Apart from "soft" factors, such as simplified customs procedures or "information capacity", the condition of both linear and nodal infrastructure, on which the price and time of transport largely depend, and thus the scale of use of a given transport corridor, is crucial.

The throughput capacity of the Polish section of the railway Silk Road strongly depends on the activities of the PKP Group entities, as the development of linear and nodal railway infrastructure in Poland lies within their competences. However, thanks to the actions they undertake, it should be possible to increase the throughput capacity of railway routes on the main transport corridors, and to improve the reloading area and reloading terminals within a few years. This should allow for better handling of goods' flow and shortening the time of goods' transport through the territory of Poland.

Considering the above, there seem to be strong reasons for Poland to be an "intermodal logistics hub" for the incoming commodity flows from China, covering both Central and Western European countries. The modernization of Polish railway infrastructure, carried out as well as planned, seems to be sufficient to maintain the very high attractiveness of Poland as a transit country for land freight between China and the European Union in the coming years. The conceptual work done within this paper can be useful to develop further research related to the infrastructure investment on railway freight routes in UE.

We believe that this study provides a comprehensive overview of the main rail freight routes connecting China and the EU, exploring their development determinants, barriers, and challenges. It examines the role of Poland as a strategic partner and a gateway to the EU within the BRI framework, highlighting its current and prospective significance as an "international logistic hub". Also, it assesses the impact of infrastructural investments in Poland on the development of rail transport between China and the EU, using various data sources and analytical methods.

Additionally, our research addresses the implications of the Russia–Ukraine conflict for the BRI and the Eurasian land bridge. It examines the strategies employed by China and other stakeholders to navigate the evolving geopolitical landscape. The study identifies areas of cooperation and coordination among BRI participant countries, particularly in enhancing the efficiency, interoperability, and safety of railway freight transport.

We consider that this research holds practical significance as it provides valuable insights and recommendations applicable to policymakers, railway operators, and logistics service providers engaged in the BRI, particularly in Poland and other EU countries. The study aids in identifying opportunities and challenges to enhance the competitiveness and appeal of railway freight transport as a sustainable and reliable mode between China and the EU. Furthermore, it encourages dialogue and collaboration among BRI stakeholders, encompassing both public and private sectors, to collectively address shared issues and challenges. These include customs procedures, security risks, and environmental impacts.

Finally, considering the significance of the trade conflict between China and the USA and its impact on the European Union, we found out that there is limited existing literature on this subject. We regard it as a valuable avenue for future research.

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Doktorant w Akademii Leona Koźmińskiego, gdzie zajmuje się gospodarką o obiegu zamkniętym oraz efektywnością łańcucha dostaw. Posiada stopień magistra z zarządzania organizacjami zdobyty na Universidad Veracruzana, gdzie ukończył również specjalizację z metod statystycznych. Uczestniczył w wielu międzynarodowych seminariach i kongresach, gdzie prezentował swoje badania na tematy związane z zarządzaniem odpadami komunalnymi, konkurencyjnością małych i średnich przedsiębiorstw oraz analizą modeli biznesowych. Publikował także swoje badania w czasopismach naukowych i magazynach branżowych. Posługuje się różnymi narzędziami oprogramowania do analizy danych.