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ORIGINAL PAPER

PROSPECTS FOR THE DEVELOPMENT OF INTERMODAL TRANSPORT IN THE VISEGRAD COUNTRIES, GERMANY AND ITALY – SELECTED ASPECTS

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Abstract

The article presents the results of research on the possibilities of developing intermodal rail transport in the Visegrad Group countries, Italy and Germany. The research was conducted based on statistical data regarding demand for transport in intermodal cargo units and rail transport. Selected elements of transport infrastructure were taken into account as well, i.e. the length of railway tracks and railway lines (including electrified ones), the railway line density indicator, and the number of terminals. The study results proved that there was a noticeable development of infrastructure in Hungary which makes it a prospective market, affording the possibility for development of domestic and international transport. The biggest decrease for railway transport was observed in Germany and Poland. In the same time, in Poland there was observed the biggest increase in demand for intermodal container units (ICUs). The inverse relationship between demand for railway transport and ICUs is observed in most countries. Only in Czechia there was a parallel increase observed. It has been observed that linear and point infrastructure requires investment in electrification in most countries surveyed. These investments are important due to handling the needs of foreign trade. With the growing demand for transport and developed infrastructure, the intermodal rail transport will be able to compete with road transport. This process is consistent with the need to ensure green transport and modify transport structure into the environmental friendly one.

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PERSPEKTYWY ROZWOJU PRZWOZÓW INTERMODALNYCH W KRAJACH GRUPY WYSZEHRADZKIEJ, NIEMCZECH I WŁOSZECH – WYBRANE ASPEKTY

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Słowa kluczowe: V4, transport intermodalny, infrastruktura, zrównoważony transport, UE.

Abstrakt

W artykule zaprezentowano wyniki badań dotyczących możliwości rozwoju kolejowych przewozów intermodalnych w krajach Grupy Wyszehradzkiej, Włoszech i Niemczech. Badania przeprowadzono na podstawie danych statystycznych: popytu na przewozy w intermodalnych jednostkach ładunkowych i przewozy kolejowe. Ponadto uwzględniono wybrane elementy infrastruktury transportowej, tj. długość torów i linii kolejowych (w tym zelektryfikowanych), wskaźnik gęstości linii kolejowych i liczbę terminali. W wyniku badań wykazano, że na Węgrzech nastąpił znaczący rozwój infrastruktury kolejowej, co sprawia, że jest to rynek perspektywiczny, dający możliwość rozwoju transportu krajowego i międzynarodowego. Największy spadek popytu na transport kolejowy odnotowano w Niemczech i Polsce. Jednocześnie w Polsce zaobserwowano największy wzrost zapotrzebowania na przewozy intermodalnych jednostek ładunkowych (IJŁ). W większości krajów występuje odwrotna zależność między popytem na transport kolejowy a popytem na IJŁ. Jedynie w Czechach widoczny jest wzrost popytu w obydwu przypadkach. Zaobserwowano, że infrastruktura liniowa i punktowa wymagają inwestycji w elektryfikację w większości krajów. Inwestycje te są istotne z uwagi na obsługę potrzeb handlu zagranicznego. Przy rosnącym popycie na przewozy i rozwiniętej infrastrukturze możliwe będzie konkurowanie z transportem samochodowym. Proces ten wpisuje się w potrzebę ekologizacji transportu i zmianę struktury przewozów sprzyjającej środowisku naturalnemu.

Introduction and Research Background

Intermodal transport is most often defined as the conveyance of cargo units (package, pallet, container) using at least two means of carriage (Neider, 2015, p. 110; Mindur, 2008, p. 229; Bril & Łukasik, 2012, p. 77, 78). This technology is recommended in international transport to handle the needs of foreign trade (Crainic & Kim, 2007, p. 470, 471). The relatively most frequently used technology is a combination of rail transport (on the longest distance) and car transport (to ensure delivery and pickup services) (Daramola, 2022, p. 61).

There is no full agreement in the literature as to the definition of intermodal transport. However, its importance in international trade and in the process of globalization of economies is clearly indicated (Crainic, Perboli & Rosano, 2018, p. 401), and its efficiency is deemed dependent on an efficient and sustainable transport network (Liu, Deng, Sun, Wang & Wang, 2019, p. 1, 2). In addition, as concluded by Garcia-Menendez *et al.* (2014), Zhang, Heinold, Meisel, Negenborn and Atasoy (2022), Gharehgozli, de Vries and Decrauw (2019), and Mindur (2021), intermodal transport is an ecological mean for cargo movement. It may compete with road transport, which performs 50-70% of the cargo transport in the EU (depending on the adopted measure). This argument prompts research aimed to investigate the conditions for the functioning and development of intermodal transport.

Pursuant to the assumptions of the EU transport policy, 60% reduction in greenhouse gas emissions is expected by 2050 (compared to 1990). Given the thus-far ineffective attempts to implement these assumptions, the importance of intermodal transport as a competitor of road transport as well as the opportunity to push the transport into more ecological modes of operation are observed to grow (Bergqvist & Flodén, 2010, p. 4, 5; Rotaris, Tonelli & Capoani, 2022, p. 5; Szymanowski, 2014, p. 326). The development of world trade affects the development of container transport (sea and rail), which is another premise for the development of intermodal transport. In a situation where the importance of road transport diminishes in favor of an increasing demand for intermodal transport, it is possible to decarbonize the transport sector (Lebedevas, Dailydka, Jastremskas & Rapalis, 2017, p. 292) in line with the objectives of the transport development policy. At the same time, there is a positive relationship between economic development and the development of intermodal transport in some countries of Central and Eastern Europe (Silborn, 2008, p. 60; de Miranda Pinto, Mistage, Bilotta & Helmers, 2018, p. 104). It should be borne in mind, however, that organizing and monitoring intermodal supply chains requires greater organizational effort and high coordination skills (Zhao, Zhu & Wang, 2020, p. 5). The success of these activities is determined by the efficiency (including the timeliness of deliveries) and the effectiveness of intermodal transport (Demir, Hrusovsky, Jammernegg & van Woensel, 2019, p. 6162, 6163) under conditions of safe transport infrastructure tailored to needs.

On a global scale, there is a large quantitative and qualitative diversity of infrastructure. The largest number of railway lines is found in the region of Asia and Oceania (33%) and Europe (30%), followed by America (20%), the Russian Federation (10%) and Africa (7%) (*Union International des...*, 2020). An important qualitative element of the railway infrastructure is the degree of its electrification. When screened across continents, it has a high variability, ranging from 50% in Europe, 33% in Asia and Oceania, 26% in Africa and only 0.1% in America (where electric traction is only found in subway lines) (Licciardello & Ricci, 2022).

The aim of the presented research was to indicate the possibilities for the development of intermodal rail transport (IRT) in selected EU countries. The analysis includes countries with a similar level of economic development, additionally associated in the Visegrad Group (V4: Czech Republic, Slovakia, Hungary, Poland) and highly industrialized countries belonging to the G7 countries (Germany and Italy). Development opportunities were made based on the analysis of infrastructure and demand for transport. The choice of the IRT technology was driven by two reasons. The first is its importance in the process of making transport green in accordance with the guidelines of the EU transport policy. The pursuit of decarbonizing the transport sector creates a real opportunity for intermodal transport development. The safety of transport and long distance are elements inscribing into the needs of international trade, which was the second reason for choosing the IRT technology for analysis.

Methodology

The study included the V4 countries due to the similar level of GDP per capita. Moreover, these countries share common foreign policy goals and cooperation in the field of developing safe and efficient transport infrastructure. The European G7 countries were also included in the comparative analysis. Extending the analysis to industrialized countries allows for a broader look at the development possibilities of intermodal transport. Germany and Italy are important trade partners with the V4 countries, characterized by a large market potential. The European G7 countries include also France, however, it was excluded from the study due to the lack of access to analogous statistical data. Great Britain was not considered for infrastructural and geographical reasons.

Including the European G7 and V4 countries in the analysis was expected to enable the comparison of intermodal transport in countries with different levels of economic development and transport potential. All the indicated countries are partners in international trade, the needs of which can be handled by intermodal transport.

Secondary data from the Eurostat database was used to assess the development of IRT. The research extends into the years 2010-2020 and takes account of the following data:

– length of railway tracks [km] – railway tracks are a set of two rails set parallel to each other; the variable quantifies the state of the infrastructure necessary to provide the IRT;

– length of railway lines [km] – these are railway roads that may consist of one or more railway tracks; multi-track railway lines affect the capacity and speed of transport means;

– demand for rail transport – expressed in thousand tonnes;

– demand for transport in intermodal cargo units (ICUs) (in thousands tonnes);

– number of intermodal terminals – reloading and storage points for goods transported in intermodal units; the higher the number of terminals, the greater the reloading and storage capacity, which determines the possibilities for intermodal transport development and the efficiency of international supply chains.

General statistical data lacks publicly available information on intermodal rail transport at the international level. Sometimes, access to this data is paid and made available by national railway carriers. Therefore, an attempt was made to compare the possibility of IRT development under the conditions of the demand for rail transport and transport in ICUs. The ICUs can also be used in intermodal transport by sea and inland waterways.

The assessment of the possibility of IRT development was carried out deploying descriptive statistics tools based on indicators of dynamics of railway electrification and density of railway lines.

Research Results

The larger the country's area and population, the greater the potential transport needs and capacity. Moreover, the country's area determines the railway network (measured by the length of railway tracks and lines), assuming a favorable topography. Poland, which is second in terms of area among the surveyed countries, also has one of the most extensive railway networks (expressed in track length). Similarly, Germany is characterized by the largest area of the country and, at the same time, the largest railway network. Table 1 presents detailed data on the length of railway tracks in the analyzed countries (total and electrified). Information on changes in the railway network is important in determining the possibilities of providing services in individual countries. In turn, the figures regarding the electrification of the railway network are essential to the development of the quality of services, especially in the international perspective.

In 2010-2019, a decrease was observed in the total length of railway tracks in Germany (by 3% – compared to 2016), Czechia (2%), and Poland (1%). In Italy, the length of tracks increased by 1% and so did the length of electrified tracks (2%). The highest dynamics of qualitative changes was observed in Hungary, showing a 23% increase in the total length of tracks and a 40% increase in the length of electrified tracks. The Hungarian IRT market opens the possibility of meeting larger transport needs in the domestic, and what is equally important, in the international dimension. Rail electrification is a key determinant of handling international supply chains. In the other analyzed countries, the dynamics

Table 1

Length of railway tracks in selected EU countries (in thousands of km)

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Germany										
Total	69.3	69.2	69.4	69.2	69.1	67.4	67.4	n.d.	n.d.	n.d.
Electrified	44.2	n.d.	n.d.	n.d.	n.d.	42.3	42.3	n.d.	n.d.	n.d.
Italy										
Total	24.2	24.2	24.3	24.3	24.3	24.3	24.4	24.5	24.5	24.5
Electrified	19.3	19.4	19.4	n.d.	n.d.	n.d.	12.0	19.6	19.7	19.7
Czechia										
Total	15.7	15.6	15.6	15.6	15.6	15.6	15.5	15.5	15.5	15.4
Electrified	6.8	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Slovakia										
Total	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Electrified	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Poland										
Total	37.8	38.1	37.6	36.9	37.5	37.6	37.4	37.2	37.1	37.3
Electrified	25.2	25.2	25.1	25.0	25.0	24.9	24.9	24.9	25.0	25.2
Hungary										
Total	9.2	9.4	9.4	9.5	9.4	9.4	11.4	11.5	11.3	11.3
Electrified	4.0	4.1	4.1	4.1	4.0	4.1	5.4	5.5	5.5	5.6

n.d. – no data available
Source: own elaboration based on the Eurostat database.

of changes in the length of electrified tracks was much lower (Germany – 1%, Czech Republic – 1%). In contrast, in Poland and Slovakia, the length of electrified tracks was relatively constant.

Railway lines differ from railway tracks by the fact that lines can consist of one or more tracks at different sections (distances). This underlies the difference in their length. Table 2 presents the length of railway lines (total and electrified). Multi-track lines enable an increase in train traffic (possibility to handle more orders), free passing, and the possibility of separating freight and passenger traffic, which enables IRT optimization. Therefore, they set a higher level of service provision, e.g. minimizing delays and offering greater flexibility in redirecting trains in the event of adverse events.

In 2010-2019, no changes were observed in the length of railway lines (total and electrified) in Czechia and Slovakia. Slight upward dynamics (less than 1%) in the electrified network development was visible in Germany and Italy. A decrease in the length of the electrified railway lines was observed only in Poland (by 6%). The greatest positive changes were noticed in Hungary – an increase in the length of electrified lines by almost 90%. Undoubtedly, Hungary has experienced the greatest qualitative change in the railway network. The extent of railway electrification in this country is also noteworthy as it reaches 71%, which should be assessed positively. This is a level comparable to the railway network in Italy (71%). In the other analyzed countries, the degree of railway electrification was lower and amounted to 54% in Germany, 33% in Czechia, 44% in Slovakia, and 58% in Poland.

Table 2

Length of railway lines in selected EU countries (thousand km)

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Germany										
Total	37.9	37.8	37.9	37.9	37.8	38.5	38.6	38.6	38.4	38.4
Electrified	20.6	n.d.	n.d.	n.d.	n.d.	20.7	20.7	n.d.	n.d.	n.d.
Italy										
Total	16.7	16.7	16.7	16.7	n.d.	n.d.	16.8	16, 8	16.8	16.8
Electrified	11.9	1.9	11.9	11.9	n.d.	n.d.	12.0	12.0	12.0	12.0
Czechia										
Total	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Electrified	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Slovakia										
Total	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Electrified	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Poland										
Total	20.2	20.2	20.1	19.3	19.2	19.2	19.1	19.2	91.2	19.4
Electrified	11.9	11.9	11.9	11.9	11.8	11.9	11.9	11.8	11.9	11.2
Hungary										
Total	7.4	7.5	7.5	7.4	7.2	7.2	7.8	7.9	7.7	7.7
Electrified	2.9	2.9	3.0	3.0	3.0	3.0	3.0	5.5	5.5	5.5

n.d. – no data available
Source: own elaboration based on the Eurostat database.

The analysis of the railway infrastructure was extended by the total railway line density index (TRLDI) and the electrified railway line density index (ERLDI), calculated using the following formulas:

$$\mathrm{TRLDI} = \frac{\text{total length of railway lines [km]}}{\text{country's area [km}^2\text{]}} \cdot 100$$

$$\mathrm{ERLDI} = \frac{\text{length of electrified railway lines [km]}}{\text{country's area [km}^2\text{]}} \cdot 100$$

The calculations provided interesting information, and their graphical presentation is shown in Figure 1. Czechia, which is one of the smallest compared countries (in terms of area), is characterized by the highest density of railway lines (12.2 km of railway lines per 100 km² of the country area); however, it performs slightly worse considering the density of electrified lines. Undoubtedly, the most favorable situation is observed in Germany and Hungary, where the density of the electrified railway network is the highest.

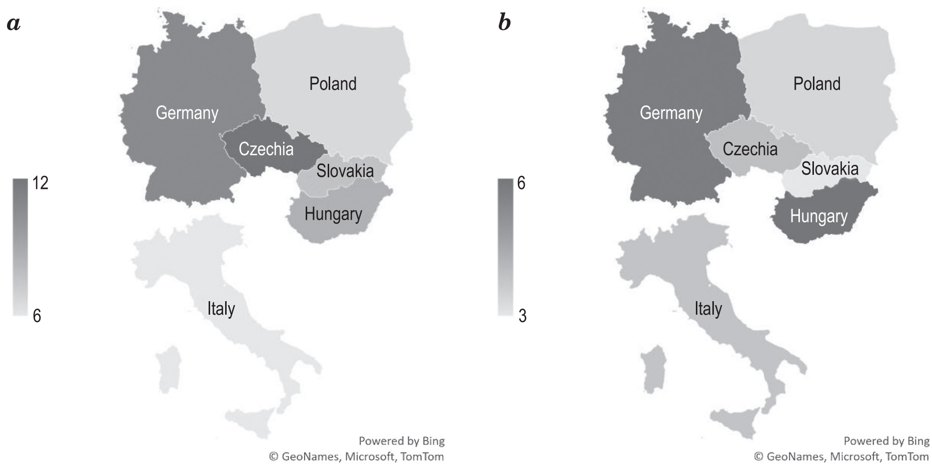

Fig. 1. Density indicators of total and electrified railway lines in selected EU countries: *a* – TRLDI, *b* – ERLDI

Source*:* own calculations based on EUROSTAT data.

Untapped potential can be observed in Poland, whose geographical location is advantageous due to the fact that it shares 3 European transport corridors (No. 5 – Baltic Sea – Adriatic Sea, No. 8 – North Sea – Baltic Sea, and No. 11 – Amber Rail Freight Corridor). Poland is also important in reactivating the New Silk Road and providing IRT services on it. However, a low degree of electrification of its railway network diminishes its potential to provide international IRTs. This is where an opportunity opens up for Hungary, which has a qualitatively better railway infrastructure. Countries with high railway network density (especially of the electrified one) represent an attractive IRT market, which provides a high level of services, especially in international transport.

The development of IRT is enabled by a well-developed point infrastructure, including e.g. intermodal terminals adapted to reloading and storing intermodal cargo units. In addition to reloading, terminals merge logistics and distribution services and determine the possibilities for the efficient functioning of international supply chains. The higher the number of terminals, the greater the negotiation possibilities in the context of import-export operations and competitiveness compared to road transport. Depending on the location, terminals can handle several modes of transport (rail, road, air, sea and inland waterways). The only (known to the authors of this manuscript) statistics related to intermodal terminals in the analyzed countries are presented on the website of the intermodal transport operators consortium (AGORA Intermodal terminals). However, an interactive map available therein and showing the number of terminals prevents historical data collection. Table 3 summarizes the number of terminals in the analyzed countries and provides the characteristics of the cities with the largest number of terminals. It should be emphasized that the location of the terminals takes into account the profile of transport and logistics activities of a given region. These are places that require a lot of logistical support in the strategies of operation.

Table 3

Intermodal terminals in selected EU countries in 2020

Country	Number of intermodal terminals	The city with the highest number of terminals
Germany	140	Duisburg – inland waterway port
Italy	19	Trieste – seaport
Czechia	16	Lovosice – inland waterway port, high-speed railways to Czechia and Germany
Slovakia	10	Bratislava – the capital city
Poland	40	Małaszewicze – terminals with broad-gauge infrastructure, end station for 90% of transports from Asian markets
Hungary	6	Budapest – the capital city

Source: own study based on Intermodal Terminals in Europe. (2022); Duisport: Facts and figures. (2022); The Free Port of Trieste. (2022); Město Lovosice. (2022).

Noteworthy is the significant difference in the number of terminals in Germany, being over 3 times higher than the number of terminals in Poland. Another important observation is the comparable number of terminals in Czechia and Italy, despite four times larger area of Italy. In turn, the number of terminals in Slovakia is greater than in Hungary, whose area is almost twice as large. The construction of intermodal terminals paves the way for the development of transport activities. Most often, they are located in the vicinity of ports (Duisburg, Lovosice, Trieste) and capitals of countries (Bratislava, Budapest), have features that allow them to handle specific transport requirements (Małaszewicze) and are well connected to road infrastructure.

Another important piece of information in identifying IRT development opportunities is demand for railway transport. One of the measures of demand in transport is transport performance [ton-kilometers – tkm]. The analysis also takes into account the demand for transport in intermodal cargo units (ICUs).

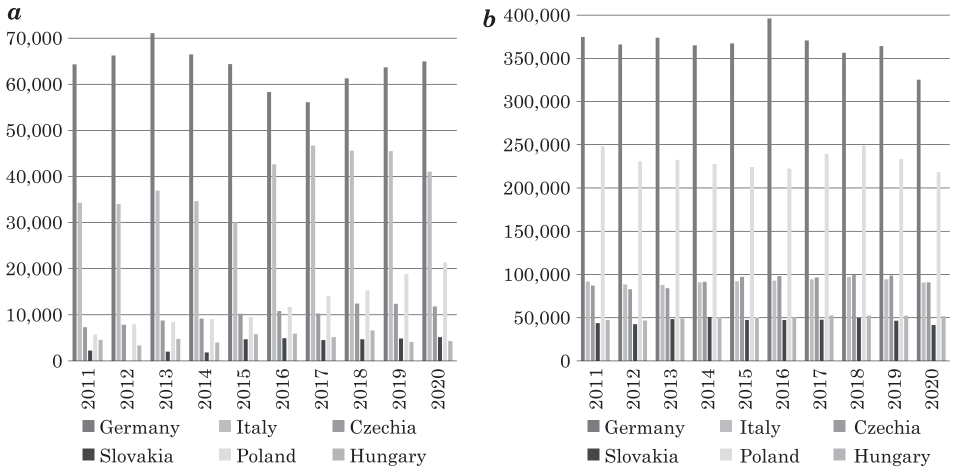

Fig. 2. Demand for railway transport and intermodal cargo units in 2011-2020 (thousand tonnes): *a* – intermodal transport, *b* – railway transport
Source: own calculations based on EUROSTAT data.

Comparing this information will allow for an in-depth analysis of the possibility of IRT development. The time range covers the years for which similar statistical reporting was carried out, i.e. from 2011.

The biggest decrease for railway transport was observed in Germany (13%) and Poland (12%). The worth noting thing is that in Poland there was the biggest increase in demand for ICUs (271%) while in Germany the demand was rather stable (1% increase). The increase in demand for ICUs was also relatively high in Slovakia (129%) while there was observed a 5% decrease in the demand for railway transport. What is important the inverse relationship between demand for railway transport and ICUs is observed in most countries. Except for Poland and Slovakia, also in Italy (a 1% decrease for railway transport and a 20% increase for ICUs), and Hungary (a 9% increase and 5% decrease). Only in Czechia there was increase in both cases: a 4% for demand for railway transport and 61% for ICUs. The increase in the demand for ICUs is needed and may indicate an opportunity for IRT development because this technology needs to be implemented in and can be exchanged between the analyzed countries due to both the need to ensure environment-friendly transport and to optimize supply chains. The use of ICUs in maritime transport is questionable, as is inland waterway transport, which is of marginal importance in intra-EU trade.

Conclusions and Discussion

The denser the railway network and the higher the degree of its electrification are, the greater the chances are for providing IRT in individual countries, but also in international trade. The railway infrastructure is an important element of IRT development. It has to be mentioned that in future analysis of cost per tkm should be calculated as a one of crucial factors of development. Undoubtedly, qualitative changes in the railway network afford opportunities for IRT development. It also opens the possibilities for foreign carriers to enter into the market. Considering the V4 countries, the noticeable development of infrastructure in Hungary may contribute to the development of foreign competition and transit services. It is also important to develop point infrastructure – intermodal terminals, the scarcity of which does not allow to sufficiently exploit the IRT potential. Given the fully liberalized railway transport markets, foreign competition will also contribute to the qualitative development of the offer, and with a developed infrastructure, it will allow, among others, to compete in the promptness of deliveries with road carriers. This approach is part of the process of making transport green and modifying transport structure into the environment-friendly one.

The prerequisite for the development of IRT is also the extension of the logistic base in the form of terminals adapted to handle ICUs. It is important that the intermodal terminals have the potential to handle rail transport, regardless of its location.

Observing changes in demand allows assessing the attractiveness of a given market in terms of potential expansion. The German and Italian markets will always be attractive due to trade exchange. The extensive German infrastructure and investments in Italy are additional factors supporting the development of IRT in relations to/from these countries. In addition, they are an element encouraging the expansion of private carriers. The potential of these markets should be described as very competitive.

An increase in the interest in IRT within the framework of the New Silk Road can be expected after the end of the war in Ukraine. This is another chance for IRT development. Consideration of the structure of exports and imports indicates avenues for further research on IRT and for determining the transport offer. The construction and modernization of the railway network may contribute to the increase in the quality of services, and thus to the development of intermodal transport. Determination of the technical possibilities of providing services and analysis of the demand make it possible to identify markets that are potentially attractive to foreign carriers. It seems that geographical potential is essential as well, which in the case of the V4 countries could be exploited both in intra-EU and intercontinental trade.

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