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# Maturity of Polish Rail Intermodal Transport as Compared to Selected EU Countries: A Comparative Analysis

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***Abstract:***

***Purpose:*** *The aim of this paper is to propose a maturity construct for rail intermodal transport and, based on it, to present a comparative analysis for Poland and four selected EU countries.*
***Design/Methodology/Approach:*** *The development of intermodal transport is the main assumption of the EU transport policy. It is part of the idea of sustainable development and the aim to reduce the external costs of transport. In Poland, intermodal transport is carried out mainly in the road-rail relation, hence the focus of this paper is on this combination of transport branches. The paper uses a comparative analysis. Two groups of parameters were proposed to describe the construct of intermodal transport maturity. The first describes the level and dynamics of intermodal freight flows. The second indicates the existing infrastructural conditions of performed flows. The analysis allowed to present the level of Poland's intermodal transport maturity against the background of four countries with the highest share of intermodal transport in total freight flows.*
***Findings:*** *The developed construct allowed to assess Poland's maturity in intermodal transport against the background of other European countries. This comparison allowed to indicate possible deviations of Poland from the analyzed countries in the area of the analyzed infrastructural conditions.*
***Practical Implications:*** *The analysis carried out in this paper allows to point out the directions of further research. They oscillate around the comparison of the maturity of a wider group of countries or regions and extending the research to other forms of intermodal transport.*
***Originality/value:*** *The adopted approach to assessing intermodal transport is not limited to the most recognised indicator in literature, i.e., the share of intermodal transport in total freight flows or the comparison of its dynamics in time. Its advantage is the possibility of relating this dynamics to the organizational, legal and economic conditions that constitute the potential for intermodal transport development.*

***Keywords:*** *Intermodal transport maturity model, comparative analysis, freight flows, strategy of intermodal transport.*

***JEL codes:*** *R41, Q58.*

***Paper type:*** *Research article.*

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## 1. Introduction

Intermodal transport is supported by the adopted strategic assumptions of the European Union (EU), included in the basic document - the White Paper (European Commission, 2011). Striving for its development is the result of a significant imbalance in the structure of freight transport in Europe, in which road transport has the largest share (Tawfik and Limbourg, 2019; Kreutzberger and Konings, 2016). EU policy aims to reduce the external costs of transport (Tawfik and Limbourg, 2019), balance the various industries and increase their role in freight by creating a fully functioning intermodal transport network by 2030 (Mindur, 2018). As assumed, intermodal transport uses different modes of transport. In Poland, in the context of continental intermodal transport, the main focus in freight transport is on rail, creating intermodal road-rail chains. This is the result of, on the one hand, the extensive railway network, and, on the other hand, the poor condition of inland navigation, which is not currently able to relieve road transport.

Poland, lying at the crossroads of important trans-European transport corridors, has a chance to become a significant intermodal junction of Central Europe. In recent years, the intermodal rail transport services performed have been characterized by constant and successive development. However, their size is still too low, an unsatisfactory level, especially in comparison with the EU countries with an extensive railway network. Thus, a question arises about the maturity of intermodal railway transport systems in various European countries and the position of Poland against them. The concept of maturity, especially in process management and in relation to organization, is already strongly defined and for many years it has been improved in theory, methodically and empirically.

However, in the context of transport systems, and especially intermodal transport, there is a research gap in the definition and recognition of the concept of maturity. There are no guidelines indicating the elements building the intermodal maturity of the transport system and allowing for assessment and comparisons in this respect. Hence, the aim of the paper was to propose a maturity construct for intermodal rail transport and on its basis to present a comparative analysis for Poland and four selected EU countries.

In the first part of the paper, a theoretical analysis was carried out to identify the concept of maturity in management and quality sciences and to indicate the parameters describing the intermodal transport maturity construct. The second part presents the methodology of the research based on comparative analysis. The third part presents the research results along with the final conclusions.

## 2. Literature Review

Maturity means the systematic improvement of the organization's skills, as well as the processes implemented in it, in order to obtain higher efficiency within a given

period of time (Hammer, 2007). In this sense, the maturity model is a set of various tools and practices that enable the assessment of an Organization's Management Competences, as well as the improvement of key factors leading to the achievement of the assumed goals (Looy, 2014). OMG (Object Management Group) (2008) defines maturity models as an evolutionary process of implementing key practices in one or more areas of the company's operation. The adopted maturity levels allow the organization to improve its practices, starting from undefined and inconsistent practices and processes, through repetitive practices at the level of organizational units, then comprehensively defined business processes (statistically predictable and managed), up to the continuous process of implementing innovation and optimization.

Thus, maturity models define the current state of the organization, which results from the way the organization operates, the possibility of using the resources or experience gained so far, as well as goals that can be achieved in the future by setting priorities for activities and identifying measures and methods of their implementation. This interpretation of the maturity model, transferred to the intermodal maturity of rail freight flows, indicates the implementation of the main goal of increasing the share of intermodal transport using a number of attributes, including infrastructural, political, economic and legal.

The first attempts to develop a matrix describing the organization maturity levels were made by Crosby (1980), who presented the quality management maturity grid. The grid included 6 categories and 5 levels of maturity. The category includes: attitude and understanding of quality problems among the management, the status of the quality organization, the treatment of problems, quality costs, activities improving quality, the attitude of the company. The levels included: insecurity, awakening, enlightenment, wisdom, and confidence.

Research on maturity assessment methods describing sequentially increasing organizational effectiveness was carried out in 1986-87 at Carnegie Melon University (Humphrey, 1989). Further work led to the development of a Capability Maturity Model for Software (CMM). Since the first publication of SEI's organizational maturity model in 1993, the idea has been replicated in many business areas, including project, program and portfolio management. In 2002, the Capability Maturity Model Integration (CMMI) was published. The model was updated in 2006 and 2010 (CMMI, 2017). Its variations were introduced for services, development activities and human resource management. The model defines 5 levels of maturity, which are named respectively: initial, managed, defined, quantified and optimized.

Borys and Rogala (2013) drew attention to the multi-level nature of the concept of maturity, and this view, taking into account the historical determinants of the maturity construct, seems to be correct. At the level of assessment of the entire organization, one can speak of synthetic, aggregated maturity. Such a proposal is included, for example, in the ISO 9004 standard. When analysing the individual

functions of an organization, partial maturities can be distinguished, for example: organizational and management, process, technological, qualitative, cultural, information management, employees and knowledge management. They are the subject of research by scientists, but so far mainly models in the field of software design and project management have been popularized. Moreover, a second level of maturity decomposition can be indicated, which may be related to the individual features of fitness in a synthetic approach (Borys and Rogala, 2013). And again, translating these experiences into the intermodal maturity of rail freight transport, infrastructural, political, legal and economic attributes become partial maturities.

Skrzypek (2014) points to the criterion of efficiency, emphasizing that the maturity of an organization is primarily related to a high level of various forms of management efficiency (efficiency, effectiveness). This is clearly visible in the CMMI model, in which the vast majority of evaluation criteria concern the tasks of managers (decision making, measurement and analysis, process definition, product and process quality assurance, risk management, etc.). Thus, in the construction of the maturity of intermodal rail freight transport, the share of intermodal rail transport in total freight flows in rail transport was adopted as the effectiveness measure.

Achieving the aggregate level of maturity is conditioned on meeting all sub-criteria of a given and lower levels. Therefore, this assessment does not differentiate the importance of the criteria. Some criteria may cause difficulties in interpretation. These problems can be solved by applying a more advanced aggregation method and refining the criteria.

In recent years, the concept of maturity has been developed not only in relation to the sector or enterprise, but also in relation to the city. In this trend, transport is treated as one of the criteria assessed in terms of being in line with the idea of a smart city (Smart City Redines, 2014). Studies that are important in the field of freight transport were conducted in 2018-2019 (Alons-Hoen *et al.*, 2021). As a result of this research, a maturity model was developed to make companies aware of several aspects of the organization of synchromodal transport.

The level of companies' maturity was assessed by means of a questionnaire. The questions were developed and approved by staff from the Fontys University of Applied Sciences and the Rotterdam University of Applied Sciences. The authors used a 5-point scale to which they assigned factors characterizing the maturity of the organization to implement synchromodal transport. The results of these studies are a significant contribution to the maturity area of a freight-oriented organization and confirm the validity of multi-level construction of maturity. However, they do not fill the gap related to the transfer of research burden from enterprises to the macrologistic system, which is intermodal rail transport. The authors of this paper undertook this task by proposing a construct of intermodal maturity of rail transport.

Intermodal maturity of rail transport will therefore be understood as the degree of development of the ability to implement intermodal transport in rail transport, measured by the share of intermodal transport in total freight flows in rail transport, which consists of partial maturities composed of infrastructural, geopolitical and economic factors. The paper focuses on the infrastructural factors.

The development of intermodal transport and, consequently, the level of maturity it achieves are strongly related to the environmental conditions, which on the one hand generate opportunities and, on the other hand, barriers. These conditions are of a technical, organizational, economic and legal nature.

In building a mature railway intermodal transport system, the infrastructure and investment projects implemented in this area play a very important role. Infrastructure planning and financing only from a national perspective does not work for intermodal transport, especially due to its cross-border nature. Hence the need for commitment and support from the EU (Dimitriou and Sartzetaki, 2020). A key infrastructure issue is network access, which is often a problem for freight transport. This is mainly due to the lower density of the rail network compared to the road network.

Moreover, there is often a need to compete for access to the network between passenger and freight trains (Crozet, 2017). The issue of infrastructure, and especially its quality, also translates into two basic parameters important for the development of freight transport. The first is the average speed of trains, which in many cases is too low, which is reflected in the length of the journey. The second is overall efficiency, which is reduced due to low speed and long transport times. Another important aspect influencing the conditions for the development of intermodal transport are the commonly accepted charges for access to infrastructure. Crozet (2017) indicates Poland as a country where these fees are high, while, for example, in Germany or Great Britain they are relatively low.

When talking about infrastructure and its role in building the maturity of intermodal rail transport, one cannot ignore the importance of intermodal transshipment terminals. A necessary condition is the creation of a sufficiently dense network of various types of facilities covering the entire country, enabling efficient reloading between railways and other modes of transport. Such a network should be consistent with the European rail network, and the newly created terminals should cooperate with the already existing terminals in Europe (Antonowicz, 2018).

Kreutzberger and Konings (2016) indicate the need to build a network of terminals based on the Hub & Spoke idea. They pay attention to the reloading function of terminals not only in the standard road-rail approach, but also in the rail-rail relation. This type of network would increase the efficiency of transport and reduce costs by creating full-train transport, in which multi-car trains with a length of 600-700m would become the standard. Moreover, it is also important to equip terminals based

on innovative and intelligent solutions, directionally compatible with the digital revolution (Antonowicz, 2018).

The development of intermodal rail transport towards a high level of maturity requires a lot of support through coherent policy at all levels of its making. The role of policy makers is to create an environment for an efficiently functioning intermodal market, to make people aware of the possibilities and advantages of intermodal transport, as well as to create a system of assistance in the form of financial subsidies (Macharis *et al.*, 2011), which can compensate for the high fixed costs incurred (Tawfik and Limbourg, 2019). EU experts emphasize that railways will not become a modern mode of transport, if the conditions for full and real liberalization are not created for them, and if rail transport, and consequently combined transport, does not receive the necessary support (Mindur, 2018). The effective development of intermodal transport is seen in the coordinated actions of the Member States, consisting in the actual promotion of environmentally friendly modes and technologies of transport, especially railway (Mindur, 2018).

The intermodal transport system requires the involvement of many different entities cooperating with each other at various stages of cargo flow: forwarders, carriers, infrastructure managers, institutional authorities, cargo recipients. The cooperation established between the individual participants of the chain and the related level of information and knowledge exchange as well as the achieved level of synchronization and coordination of activities within the flow of goods strongly affect the maturity of intermodal transport (Crainic *et al.*, 2018).

A significant role is assigned to transport infrastructure managers who do not provide the transport service itself, but influence the efficiency of the transport network, optimization of infrastructure use or the technologies used. Institutional bodies also play a key role in the development of intermodal transport, by creating transport policy, creating possible incentives and regulating transport activities. These authorities are both national, including regional, and supranational (e.g. the European Commission) (Crainic *et al.*, 2018).

Among a number of regulations, the internalisation of external costs is also mentioned, which is indicated as a solution aimed at encouraging the transition to intermodal transport (Tawfik and Limbourg, 2019; Macharis *et al.*, 2010). The literature also emphasizes the importance of the railway companies themselves, which were forced to make profound changes in their structure and services offered. Only thanks to this, they can compete on the market, especially with road transport entities (Crozet, 2017).

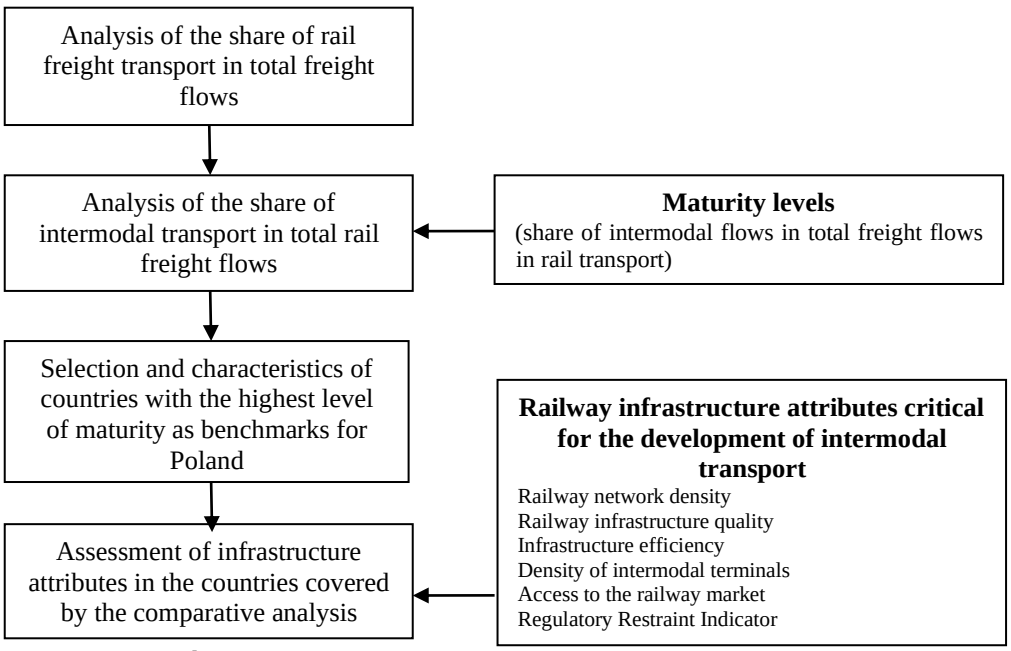
The above analysis made it possible to identify the attributes of the railway infrastructure critical for the development of intermodal transport. In further research conducted by the Authors, they will be assessed and compared in relation to Poland and four selected EU countries.

## 3. Research Methodology

In the conducted research, the maturity of intermodal rail transport was determined on a 5-point scale, in line with the proposals indicated in the literature. The effect of the intermodal maturity of rail freight is the percentage of intermodal rail transport in relation to the total rail freight. This dimension was the basis for the separation of the various levels of maturity. For EU countries, the average share of intermodal transport in rail freight transport is less than 28% (27.8%). The average value allowed for the creation of compartments in the maturity levels. Thus, the following scale was adopted: 1st level of maturity (0-10%); 2nd maturity level <10-20%); 3rd level of maturity <20-30%); 4th maturity level <30-40%); 5th maturity level <40-100%>.

The very structure of intermodal transport indicates the involvement of the available railway infrastructure in intermodal transport. However, it cannot be considered without an analysis of the structure of total rail freight flows in individual countries. With this in mind, this analysis was the first step in the research. Only in the second step, the countries that carry out more than 10% of freight flows by rail transport were analysed in terms of the share of intermodal transport in rail freight flows (Fig. 1). The EU countries were analysed. The data on the structure of flows relate to the years 2018-2019.

***Figure 1.*** *Methodology of the conducted research*




***Source:*** *Own study.*

The countries selected for the comparative analysis were characterized in terms of: country area, population density, GDP size, GDP per capita, geographical conditions, cooperation in the field of export and import, level of industrialization. All these parameters have an impact on the shaping of the country's transport system. In the next stage of the research, the authors analysed the infrastructural attributes in individual countries that were identified at the stage of literature research, including the density of the railway network and the density of intermodal terminals. They also included: the logistics efficiency index (data from 2016), market access of non-core enterprises and the infrastructure quality index according to the World Economic Forum (data from 2017), as well as the OECD regulatory constraint index. These are the indicators proposed, inter alia, in the report of the European Commission (2021).

The Logistics Performance Index was developed by the World Bank. The data used in the classification of countries comes from a survey conducted by logistics specialists. They are asked questions about the foreign countries in which they operate. This index is a weighted average of a country's performance against the identified six key dimensions: efficiency of the billing process, quality of commercial and transport infrastructure, ease of organizing shipping at competitive prices, providing high-quality logistics services, the ability to trace and track shipments, and timely shipments in terms of arriving at the destination according to the scheduled or expected delivery time.

The Regulatory Restriction Index incorporates the selected OECD regulatory indicators in the energy, transport and communications sectors. They summarize the implementing rules for passenger air transport and road freight transport (2013). The index scale ranges from 0, the least restrictive, to 6, the most restrictive. Data is collected every 5 years. The market access of all but major companies (the total market share of all railway undertakings except major) can be taken as an indicator of the level of competition in the rail sector.

Taking into account the regional specificity and the differences in the transport patterns, the indicator that can make it possible to compare the situation among EU countries is also the indicator of satisfaction with the quality of transport infrastructure. It is produced by the World Economic Forum for the purpose of producing a global competitiveness report. It is composed of satisfaction indicators with regard to the quality of road, rail, maritime transport (access to ports by inland countries) and air infrastructure. The indicators combined in this way provide a perspective for assessing the intermodal preparedness of individual countries, taking into account various modes of transport. A 7-point scale is used to compile the indicators (1 = very underdeveloped / among the worst in the world; 7 = extensive and efficient / among the best in the world. The period covered by the research is 2016-2017. On the basis of infrastructural attributes, the similarities and differences between Poland and countries with high intermodal maturity were indicated.

## 4. Results and Discussion

### 4.1 Identification of Countries for Benchmarking

The European Union countries differ significantly not only in the share of intermodal transport in total rail transport, but also in the branch structure of freight transport. Indicating positive trends in the development of intermodal rail transport, a decision was made to narrow the research to those countries where rail transport accounts for more than 10% of total cargo flows. Among them, 5 countries were identified with the highest share of intermodal transport in rail transport (Table 1). The research took into account the EU countries, in Table 1, Cyprus and Malta were omitted due to the lack of data on the analysed parameters. The first criterion compares data from 2018-2019, indicating the direction of changes in rail freight flows. In line with the assumptions adopted in the methodology, based on the second criterion (the share of intermodal transport in rail freight flows), all countries were assigned levels of intermodal maturity.

***Table 1.*** *Levels of maturity of intermodal rail transport in the studied countries*

| Country | Share of railways (in tkm) in freight transport - 2018 [%] | Share of railways (in tkm) in freight transport - 2019 [%] | Increase (+) / decrease (-) of the share of railways in freight transport [%] | Share of intermodal rail freight transport (in tkm) in total rail freight transport [%] | Maturity level |
|---|---|---|---|---|---|
| Lithuania | 67.9 | 67.4 | -0.5 | 3 | 1 |
| Estonia | 46.2 | 42.0 | -4.2 | 2 | 1 |
| Slovenia | 35.3 | 35.5 | +0.2 | 35 | 4 |
| Slovakia | 32.6 | 31.0 | -1.6 | 8 | 1 |
| Austria | 31.5 | 30.8 | -0.7 | 13 | 2 |
| Sweden | 30.6 | 30.6 | 0 | 13 | 2 |
| Finland | 29.0 | 26.9 | -2.1 | 2 | 1 |
| Romania | 28.9 | 26.8 | -2.1 | 7 | 1 |
| Czech Republic | 27.6 | 26.2 | -1.4 | 17 | 2 |
| Hungary | 27.0 | 26.3 | -0.7 | 16 | 2 |
| Polish | 26.8 | 24.0 | -2.8 | 10 | 2 |
| Croatia | 21.2 | 22.8 | +1.6 | 15 | 2 |
| Germany | 18.9 | 18.8 | -0.1 | 29 | 3 |
| Bulgaria | 19.3 | 21.1 | +1.8 | no data | |
| Portugal | 14.2 | 13.0 | -1.2 | 55 | 5 |
| Italy | 13.1 | 11.9 | -1.2 | 46 | 5 |
| Denmark | 11.8 | 11.5 | -0.3 | 34 | 4 |
| Belgium | 12.2 | 12.0 | -0.2 | no data | - |
| France | 10.0 | 9.7 | -0.3 | 17 | 2 |
| Netherlands | 6.4 | 6.3 | -0.1 | 46 | 5 |
| Spain | 5.0 | 4.8 | -0.2 | 55 | 5 |
| Greece | 2.1 | 2.5 | +0.4 | 73 | 5 |
| Ireland | 0.8 | 0.6 | -0.2 | 55 | 5 |
| Latvia | 75.8 | 73.6 | -2.2 | 1 | 1 |
| Luxembourg | 8.1 | 6.9 | -1.2 | no data | - |

***Source:*** *Own study (UIRR and UIC 2020).*

On the basis of the assumptions made by the authors, the following were selected for further research (Table 1), Portugal, Italy, Slovenia, Denmark and Germany (maturity level 4 and 5). The Netherlands (maturity level 5) was omitted due to the fact that it does not meet the first adopted assumption (at least 10% share of rail transport in cargo transport).

### 4.2 Characteristics of the Compared Countries

The above-mentioned countries have been characterized taking into account the parameters influencing the shaping of the freight transport system (Table 2).

***Table 2.*** *Selected parameters describing the analysed EU countries (2019)*

| | Country area [km$^2$] | Population [million people] | Population density [people / km$^2$] | GDP [billion USD] | Share in EU GDP [%] | GDP per capita [USD] | Industry level in the economy [%] |
|---|---|---|---|---|---|---|---|
| Italy | 302 072.84 (72nd place in the world) | 60.55 | 200.45 | 2004 | 12.8 | 33205 | 19.4 |
| Portugal | 92391 (110th place in the world) | 10.23 | 110.72 | 239 | 1.5 | 23214 | 18.5 |
| Slovenia | 20273 (150th place in the world) | 2.08 | 102.60 | 54 | 0.3 | 25933 | 27.2 |
| Denmark | 43098.31 (130th place in the world) | 5.77 | 133.88 | 350 | 2.2 | 60186 | 18 |
| Germany | 357578 (64th place in the world) | 83.52 | 233.57 | 3861 | 24.9 | 46467 | 25.8 |
| Polish | 312696 (69th place in the world) | 37.89 | 121.17 | 596 | 3.8 | 15521 | 25.6 |

***Source:*** *Own study (GUS, 2021; Eurostat, 2021).*

The analysed countries differ in terms of size, topography or the level of economic development. They all have access to the sea, which may constitute an opportunity for the development of intermodal transport, including rail. This is due to the possibilities offered by the combination of not only road transport with rail transport, but also rail transport with sea, thus ensuring intercontinental transport. They are particularly important due to the volume of exports and imports to non-European countries. Slovenia has the shortest coastline (approximately 47 km).

For other countries it is longer: Poland (775km), Portugal (1793km), Germany (2389km), Italy (7600km), and Denmark (7314km) are countries with a very well-developed coastline. To a large extent, countries also have a specifically shaped surface, which may be a factor influencing the shaping of the intermodal railway system.

Portugal is largely a country characterized by a upland and mountain landscape (2/3 of the country). It is characterized by one of the lowest urbanization rates in Europe, with the two largest urban agglomerations gathering almost half of the country's population around them. Italy is also dominated by upland and mountainous landscape, and more than 1/6 of the country's area is islands.

Slovenia is a very small country, mostly upland and mountainous (90% of the country is above 300 m above sea level). Almost half of the country is covered by forests, which makes it one of the greenest countries in the world.

Denmark, on the other hand, is a country where 70% of the area is located on the peninsula, the rest are 406 islands, 79 of which are inhabited. Against this background, it can be concluded that the area of Poland (lowlands constitutes 75%) is friendly to the shaping of the transport system.

All the above-mentioned countries cooperate with the EU countries the most in terms of export and import. In terms of exports, the highest share is assigned to Poland (80%), while other countries record it at the level of 56-76% (the lowest is for Italy - 56% and Germany 59%). Among other countries (outside the EU), the USA is in the foreground in terms of exports. With regard to imports, the highest share is observed for Portugal (76% of imports come from the EU), while for other countries this share is within the range of 59-70%. Among the countries outside the EU, the highest imports are definitely recorded in China.

In economic terms, among the six countries indicated, Germany and Italy stand out, which are included in the 7 richest and most industrialized countries in the world (G7). Their GDP significantly exceeds this indicator in other countries. The Italian economy, which is the third largest GDP generated in the EU, is known for its wine production and the automotive industry (e.g., Fiat, Ferrari, Maserati and others). In addition, agriculture and food processing, the clothing industry and tourism account for a large share of the economy.

The German economy is the most powerful in the entire EU, producing as much as a quarter of the entire EU GDP. Industry is essential for the German economy (mainly the sale of machinery, tools and cars), but also the production of beer and hop, as well as the refining and energy industries. Slovenia and Poland also have a high share of the industry sector in GDP. Slovenia is one of the most prosperous and developed countries in Central and Eastern Europe. It has a low share in the EU GDP generated (23 place), which is largely due to the size of the country and a small

population. Slovenia is poor in natural resources, and agriculture is also of little importance. The main area of the economy is industry, especially the wood and textile industry. Poland is the sixth EU economy in which the most developed is the automotive, food, energy, metallurgical, machinery and electromechanical, textile and clothing industry. The extraction and processing of mineral resources plays an important role.

Another analysed country is Denmark, which does not have the highest share in the generated EU GDP (11th position), but has a very high GDP per capita. The food, machinery, pulp and paper, metallurgical and construction industries are developing in the country. In addition, the extraction of energy resources (e.g., crude oil, natural gas) plays an important role. Denmark has one of the world's highest percentages of arable land and orchards. Fishing, grain cultivation and cattle breeding play an important role in the economy. Export is a very important factor in the Danish economy. About 1/3 of the country's GDP comes from exports. The last analysed country is Portugal, which among the so-called the "old union" is characterized by low parameters. After the economic crisis of 2008-2013, the country's economy returned to economic growth at the level of 2-3% of GDP per year (2015-2019). Important areas of the economy are tourism, agriculture, fishing, wine and cork production.

### 4.3 Comparative Analysis of Selected Countries

Taking into account the infrastructural attributes identified in the literature research, the countries described above were compared (Table 3).

***Table 3.*** *Comparison of infrastructure attributes of Poland and four selected EU countries*

| | Maturity level | Railway network density [km/km$^2$] | Density of intermodal terminals [per 100 km$^2$] | Access to the railway market | OECD regulatory restraint index (rail) | Logistics Performance Index | Infrastructure quality index |
|---|---|---|---|---|---|---|---|
| Germany | 3 | 10.73 | 5.98 | 40.9 | 2.3 | 4.4 | 5.5 |
| Polish | 2 | 6.20 | 1.41 | 38.1 | 2.8 | 3.2 | 3.6 |
| Italy | 5 | 5.55 | 2.52 | 41.2 | 2.8 | 3.8 | 4.1 |
| Portugal | 5 | 2.73 | 3.03 | 11.8 | 3.9 | 3.1 | 4.2 |
| Denmark | 4 | 4.74 | 2.55 | 29.0 | 2.3 | 3.8 | 4.6 |
| Slovenia | 4 | 5.96 | 2.46 | 12.1 | 3.8 | 3.3 | 2.9 |

***Source:*** *Own study (GUS, 2021; UIRR and UIC, 2020; Europejski semester – Transport, 2021).*

The density of the railway network in the analysed countries varies considerably. Germany with a highly developed railway network was indicated in the first place. Against the background of the above-mentioned countries, Poland fares well. On the European scale, it is one of the countries with an average density of the railway network, exceeding the European average. The problem, however, is the uneven

distribution of the network in the scale of individual regions of the country. The highest network density in Poland is found in the Śląskie Voivodeship (15.6 km/km2), while the lowest in the east of Poland (Podlaskie Voivodeship 3.7 and Lubelskie Voivodeship 3.9 km/km2). The next parameter (density of intermodal transshipment terminals) for Poland, compared to other analysed countries, is not satisfactory. The highest density should again be attributed to Germany.

The remaining countries have a comparable density of terminals, which can be roughly taken as 2.5 - 3 terminals per 100 km2. For Poland, the density is only 1.41 terminal per 100 km2. Also in this aspect, there is considerable regional variation in Poland. There are regions with a relatively well-developed network of terminals (e.g. Śląskie Voivodeship, density 4.05, Łódzkie Voivodeship - 3.29), which exceeds the density of most of the analysed countries. However, there are still regions where there is a shortage of functioning terminals (Opolskie, Świętokrzyskie, Lubuskie, Kujawsko-Pomorskie Voivodships).

The indicators collected in the report of the European Commission (including access to the railway market of non-major enterprises, the OECD regulatory constraint index (rail), the World Bank's logistic performance index (infrastructure element) and the World Economic Forum's infrastructure quality index) do not differ significantly in terms of compared countries. With regard to the index of access to the railway market of enterprises other than the main ones, Poland ranks among the top countries, next to Germany and Italy. The OECD's regulatory restraint index is highest in Portugal and Slovenia. In this perspective, Poland is again similar to Italy.

On the other hand, Germany and Denmark have the least restrictive policies. In both infrastructure quality and efficiency indices, Poland ranks below the results of Portugal, Germany, Denmark and Italy, while higher than Slovenia. It is worth noting that the second indicator showing the overall infrastructure used by the broadly understood (not only rail) intermodal transport is given on a 7-point scale and only Germany scored above 5, while the remaining countries obtained a result close to the average. On the other hand, Slovenia's score is significantly below the average. The infrastructure logistics performance index also highlights the differences between Germany and the other analysed countries. It is worth adding that when it comes to the global logistics performance index, 23 EU countries are among the top 50 of the 160 countries compared by the World Bank, with Germany, Luxembourg, the Netherlands and Sweden in the top four.

By comparing the obtained results of individual countries to the levels of intermodal maturity in which they were found (Portugal 5, Italy - 5, Denmark - 4, Slovenia - 4, Germany - 3, Poland - 2), it can be noticed that neither the quality of infrastructure, nor the degree of regulation or market openness does not condition the strong development of intermodal transport. This is particularly evident in the example of Germany, which all analysed parameters are at the highest level among the analysed

countries, while their maturity level was described as 3. It is only higher than the maturity level assigned to Poland.

Among the analysed countries, Poland is at the lowest maturity level (slightly exceeded the threshold for moving to the second maturity level). At the same time, it should be noted that in the case of most parameters, their assessment does not differ significantly from the assessments obtained by the other analysed countries. Only the density of intermodal terminals for Poland is significantly lower than in other countries. Therefore, they can be indicated as one of the barriers to the development of intermodal transport in Poland.

Taking into account the results of the comparative analysis, it is necessary to consider other reasons for the low intermodal maturity of rail freight transport. They may be on the side of parameters other than strictly infrastructural ones, i.e. among economic, legal or organizational factors. In addition, it is worth analysing the structure of enterprises and transported goods, which may also be the cause of a limited development of intermodal transport.

## 5. Conclusion

The conducted research concerns only one of the above-mentioned partial maturities of the intermodal maturity of rail transport, namely infrastructure. Already in this area there are fundamental research barriers in the form of the availability of data for analysis, especially in the case of new EU member states. Among the parameters indicated, the most pronounced differences in the level of maturity are the density of intermodal terminals. In the case of the remaining examined parameters, Germany is in the first place in the conducted analysis, which, according to the established levels of intermodal maturity, is at the level of 3. Portugal, with maturity level 5 in many parameters, especially in the density of railway lines, performs poorly. Therefore, only good infrastructural parameters do not guarantee high efficiency in the form of the share of intermodal flows in the total rail freight flows.

The paper proposes a construct of the intermodal maturity of rail transport. Pointing to its complexity and the results of the analyses carried out, it should be treated as a concept of further research by the authors, in which all partial maturities will be analysed. In addition to infrastructural maturity, geopolitical, economic and legal parameters will be examined, and relational maturity will also be taken into account as an additional dimension. The results indicated in these areas will be arranged in individual maturity levels, with the emphasis that the next level must meet the requirements of the previous level in all partial maturities.

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