Rail freight transport performance in the Central European region

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Abstract: Rail transport is an important branch of logistics that is widely supported by European and national institutions for its environmental friendliness and sustainability of operations. The relatively positive development of the economy in the past decade has allowed many states to increase the performance of rail freight transport. Unfortunately, the pandemic, energy crisis, and heightened global political tension slowed down the positive economic results at the end of the past decade. The paper aims to verify this statement and compare the performance of railway transport in the Central European region using the benchmarking method. At the same time, it points out some shortcomings in the influence of the state on the activities of railway transport operators and suggests possibilities for their improvement.

Keywords: rail freight transport, railroad transport performance, benchmarking, Central European region

JEL Classification codes: L92

INTRODUCTION

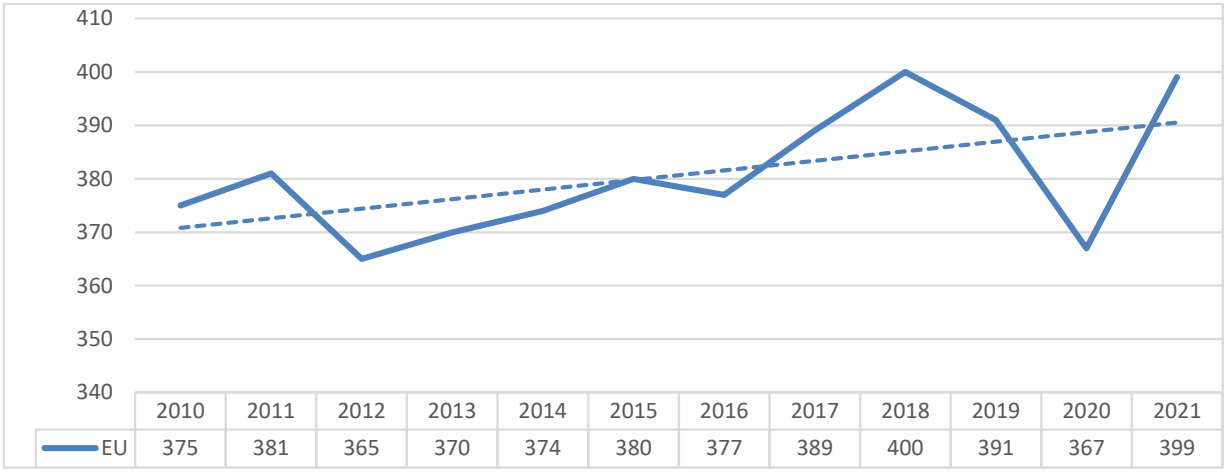
Ensuring the mobility of goods is an essential prerequisite for the proper functioning of the EU internal market and maintaining the high competitiveness of European industry and services. Functional mobility significantly helps economic growth in all sectors of the economy and contributes to the high level of employment of the population. However, with the development of transport, its negative impact on the environment and the quality of life of EU residents also increases. Transport performance in the EU, which has stabilized at roughly 2,300 billion tkm per year in the past decade, is about three-quarters provided by road truck transport (European Court of Auditors Report, 2016). The support of more efficient and environmentally friendly transport sectors is, therefore, a crucial part of the long-term transport policy of the EU and the individual member states. In the rail transport branch, the states' support primarily focused on the revitalization of the railway network and means of rail transport, as well as the transfer of cargo transport effected by road to rail routes and the inland waterway. A significant portion of the financial support of the Union is directed, among others, to the countries of Central Europe.

Rail freight transport is significantly more efficient and environmentally friendly than other modes of transportation if we measure it by ton-kilometers traveled per unit of energy consumed or greenhouse gases produced (International Energy Agency, 2017). However, moving goods by rail also has its downsides, as it involves transshipment expenses if the shipper or consignee has no direct rail access. The disadvantages mentioned can be partially eliminated by simplifying the transshipment of goods using unit trains or containerization. In some countries, railways are built and used to transport a specific type of goods or commodity

from a designated loading point to a final destination, such as from mines to an ocean port. Transport efficiency of this kind can be increased by using special railway freight cars. In these cases, freight trains are more energy economical and environmentally friendly, but their specific design reduces their usability.

The volume of goods transported by rail in the European Union gradually increased slightly over the past decade (see Fig. 1).

Fig. 1: Rail freight transport performance EU 2010-2021 in billion ton-kilometers



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
EU	375	381	365	370	374	380	377	389	400	391	367	399

Source: Eurostat, 2022

However, the volume of transport carried out by road truck transport, which is about 4 - 4.5 times higher than rail transport, grew even faster. For this reason, the share of rail freight transport in the total transport volume in the EU continues to stagnate at around 10%. Despite many measures taken by the European authorities to improve the position of rail freight transport, the development of this transport branch is unsatisfactory. The situation aptly described in the European Court of Auditors report from 2016: *Rail freight transport in the EU: still not on track*, has not yet changed too significantly. Although rail freight transport has seen some positive changes over the past decade, it has been widely affected by the ongoing epidemic and other economic and political events. A more significant increase in flexibility, quality of transport services, and labor productivity was recorded relatively rarely.

Previous studies of this kind are mainly focused on evaluating the performance of individual rail transport operators in selected countries (Sharma, 2016, Wiegmans, 2007 and others). In contrast, the present paper is based on the analysis of the performance of individual states. The state is the administrator and primarily the only investor in the railway infrastructure, which is also imposed on it by *White Paper: Roadmap to a Single European Transport Area* from 2010. In the Central European region, the state also acts as a decisive shareholder of the most essential railway freight transport operators and has a fundamental influence on their strategic decision-making. The paper can therefore serve as an incentive for the decision-making of state authorities in rail transport. The research question of this contribution can be formulated as follows: *How has rail freight transport in the Central European region developed under relatively favorable economic conditions in the past decade?* The research is based on an analysis of selected countries in Central Europe, specifically the Czech Republic, Slovakia, Poland, Austria, and Hungary. Germany was deliberately excluded from the study, as it is not considered comparable in terms of the geographically defined operational area, economic strength, and the focus of the activities of individual operators. The resulting evaluation is carried out by the benchmarking method, which shows the intensity of activities and the development of the markets in selected countries in the past decade. Only publicly available data were used to answer the research question.

1 THE POSITION OF RAILWAY FREIGHT TRANSPORT IN THE CENTRAL EUROPEAN REGION

Although railway transport in Central Europe is characterized by a long tradition dating back to the middle of the 19th century, it is characterized by significant technical and infrastructural diversity. This situation led to a lack of international integration and reduced the chance to offer flexible, reliable, and efficient services. Different types and voltages of electric traction, incompatible track gauges, disparate signaling and warning systems from country to country, and lengthy border controls still complicate cross-border traffic. For these and some other reasons, the railway network in Western Europe is better maintained and technically better equipped than in Central Europe. Although the share of rail freight transport in total inland transport performance in the EU decreased from 18% to 16% in the past decade, the level of involvement of Central European rail carriers remains relatively high. This share is around 22% in Poland and the Czech Republic, close to 30% in Slovakia and Hungary, and slightly exceeds this value in Austria (Eurostat, 2020).

The improvement of the technical equipment and the technologies used, such as the electrification of tracks, improvement of track security, the wide use of containers, and the deployment of unit and shuttle trains, took place in the past decade in the Central European region as well. However, increasing the competitiveness and fastening the position of rail freight transport depends not only on technical means but is closely related to the quality and range of provided services. The high quality of the offered services guarantees compliance with the transit time and reliability of deliveries. However, reducing transit time requires increasing the number of connections, the frequency of trains, and the wider use of modern means of transport and traffic management systems. It increases operating costs and brings the need for investments from providers and the state as well. At the same time, factors that can hinder the development of rail freight transport, such as limited track capacity or poor rail network connectivity, have also been identified (Barthel and Woxenius, 2004). Efforts must be made to improve the competitive position of rail freight transport and increase its efficiency by using all the supporting factors of development and gradually eliminating the negative ones.

The performance of rail freight transport in all EU countries, including Central Europe, is closely linked to the economic situation. The countries of Central Europe have plenty of common characteristics in terms of economic performance, focus, and available resources, which are largely influenced by a common historical development. The geographical location and political and economic situation are also reflected in the area and density of the railway network. The essential characteristics of the economy and the railway network in Central European countries are mentioned below in Table 1:

Tab. 1 Economic characteristics of the Central European countries in the year 2021

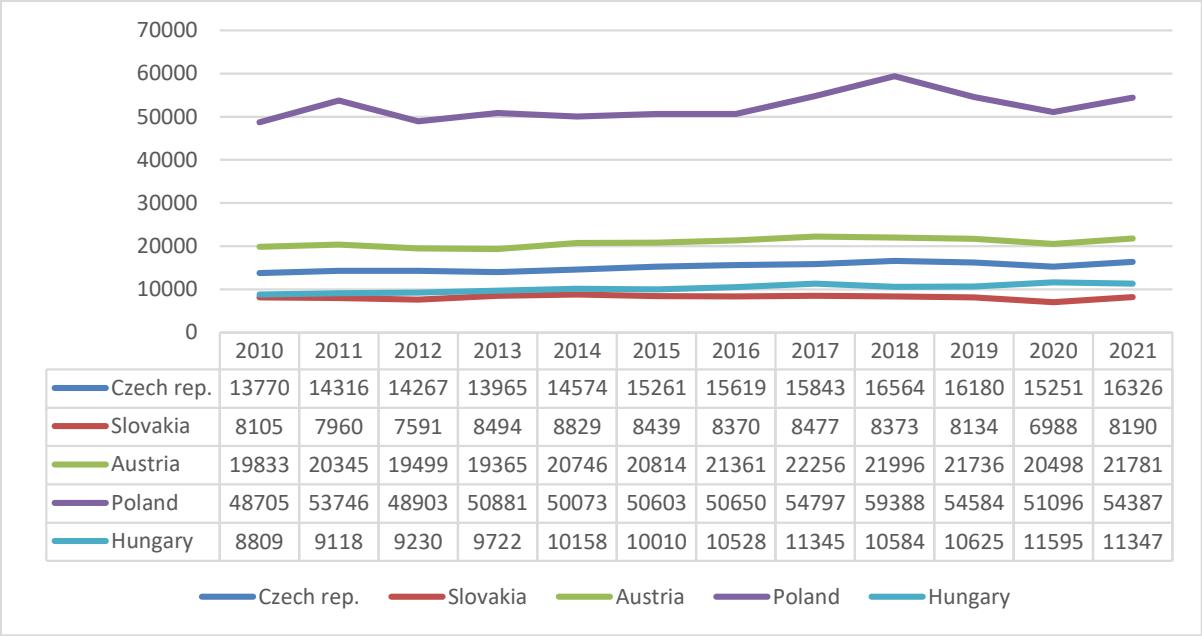
	Czech rep.	Slovakia	Austria	Poland	Hungary
Lines length in km	9 523	3 626	5 603	19 287	7 889
Land area in mil. km²	78 866	49 036	83 858	312 685	93 030
Population in thousands	10 517	5 435	8 979	37 654	9 689
GDP p.c. in mil. €	18 020	15 920	36 950	13 760	13 690

Source: Eurostat 2022

The consequences of the global economic crisis of 2008-2009 were naturally reflected in the performance of rail transport, the volumes of which returned to their previous level only after 2010. However, the development was not smooth, and volume increases were relatively low.

The positive effects were unfortunately interrupted by the global epidemic, which brought a moderate drop in performance at the end of the monitored period (see Fig. 2).

Fig. 2: Central European railways - performance in mil. tkm



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Czech rep.	13770	14316	14267	13965	14574	15261	15619	15843	16564	16180	15251	16326
Slovakia	8105	7960	7591	8494	8829	8439	8370	8477	8373	8134	6988	8190
Austria	19833	20345	19499	19365	20746	20814	21361	22256	21996	21736	20498	21781
Poland	48705	53746	48903	50881	50073	50603	50650	54797	59388	54584	51096	54387
Hungary	8809	9118	9230	9722	10158	10010	10528	11345	10584	10625	11595	11347

Source: Eurostat 2022

The development of the performance of rail freight transport in the Central European region in the past decade can be assessed as relatively positive. However, the share of rail transport in the total transport volume has hardly changed.

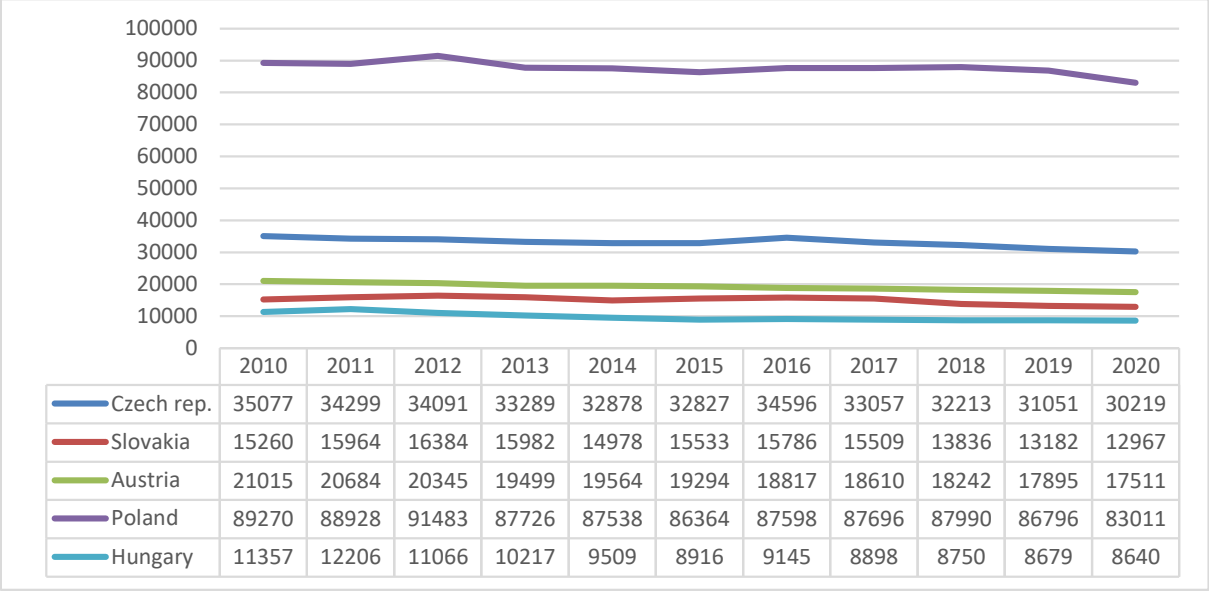
2 DEVELOPMENT OF EFFICIENCY OF RAILWAY FREIGHT TRANSPORT IN THE CENTRAL EUROPEAN REGION

Effectiveness evaluation is traditionally based on assessing the relationship between input, process, output, and result. Inputs are material and non-material resources, such as production means, workforce, or intellectual property rights, used to obtain final results. Efficiency can be measured by comparing the results of the activity - outputs, expressed in the quantity or value of disposable goods or services, with the means used to acquire them – inputs. The use of inputs to obtain final results is linked to the application of various processes, which may be based on experience and custom or may contain innovative elements. For the purpose of this paper, efficiency can be defined as the ability of the specified inputs to ensure the requested outputs, i.e., to satisfy the specific needs of customers of rail freight transport.

The efficiency of rail freight transport depends on the ability to correctly use the available inputs (wagons, drive units, track lines) to achieve the expected outputs - i.e., the correct and timely movement of the entrusted cargo. Processes in freight transport should be organized to achieve optimal results with the minimum possible costs. Malfunctions can occur for various reasons, such as when too many inputs are used or their combination is unsuitable. The reason may also be the employees' insufficient motivation or the shareholders' irresponsible behavior. The expected output may also be missed due to unexpected events - e.g., weather, state interventions, or lack of information (McCarthy, 2001).

An essential input for rail freight transport is the number of freight rail cars (wagons) with which the entrusted goods can be transported. Their number decreased slightly over the past decade (see Fig. 3).

Fig. 3: Number of rail freight cars (wagons) in pcs

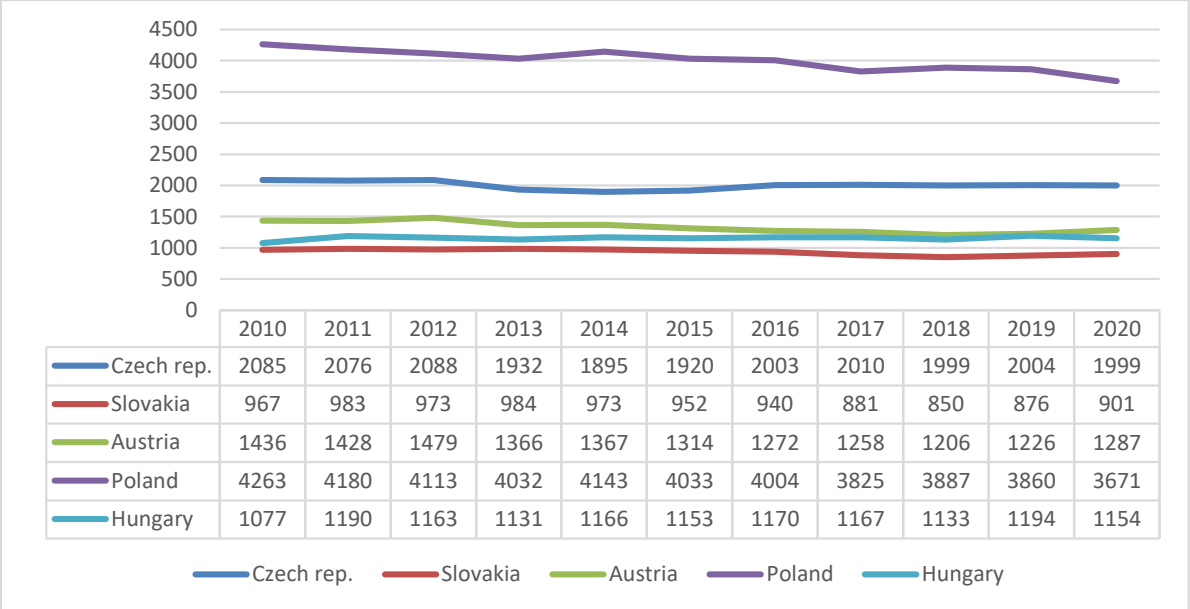


	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czech rep.	35077	34299	34091	33289	32878	32827	34596	33057	32213	31051	30219
Slovakia	15260	15964	16384	15982	14978	15533	15786	15509	13836	13182	12967
Austria	21015	20684	20345	19499	19564	19294	18817	18610	18242	17895	17511
Poland	89270	88928	91483	87726	87538	86364	87598	87696	87990	86796	83011
Hungary	11357	12206	11066	10217	9509	8916	9145	8898	8750	8679	8640

Source: Eurostat 2022

An equally important input is the locomotives used for driving the train sets. Their number also decreased over the past decade (see Fig. 4).

Fig. 4: Number of drive units (locomotives) in pcs

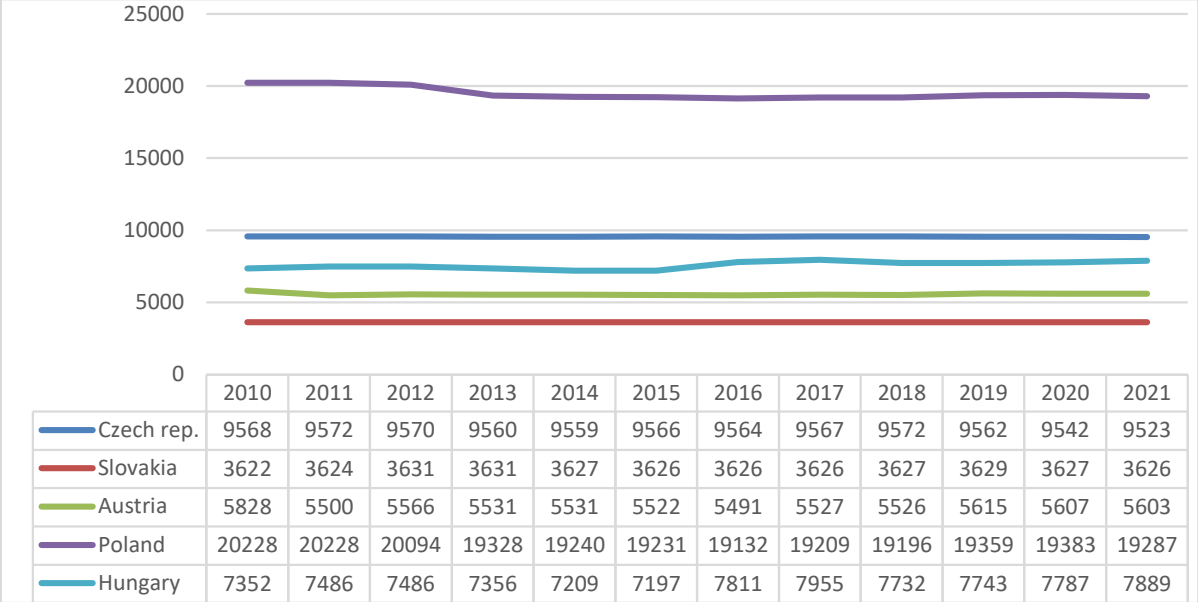


	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czech rep.	2085	2076	2088	1932	1895	1920	2003	2010	1999	2004	1999
Slovakia	967	983	973	984	973	952	940	881	850	876	901
Austria	1436	1428	1479	1366	1367	1314	1272	1258	1206	1226	1287
Poland	4263	4180	4113	4032	4143	4033	4004	3825	3887	3860	3671
Hungary	1077	1190	1163	1131	1166	1153	1170	1167	1133	1194	1154

Source: Eurostat 2022

Transport performance undoubtedly depends on the railroad lines' length, quality, and technical security. For evaluation purposes, several data are available regarding the quality of the tracks (e.g., single-track or double-track) or their equipment (e.g., electric traction). However, some information indicates that insufficient funds are invested in the maintenance and renovation of the railway network, especially in the Czech Republic and Poland (European Court of Auditor's Report, 2016). The length of the railway network itself has not changed significantly in the past decade, and its size has even decreased slightly in all countries of the Central European region (see Fig. 5).

Fig. 5: Length of railway lines in km



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Czech rep.	9568	9572	9570	9560	9559	9566	9564	9567	9572	9562	9542	9523
Slovakia	3622	3624	3631	3631	3627	3626	3626	3626	3627	3629	3627	3626
Austria	5828	5500	5566	5531	5531	5522	5491	5527	5526	5615	5607	5603
Poland	20228	20228	20094	19328	19240	19231	19132	19209	19196	19359	19383	19287
Hungary	7352	7486	7486	7356	7209	7197	7811	7955	7732	7743	7787	7889

Source: Eurostat 2022

The measurement of the efficiency of cargo transportation has recently received wide attention. The efficiency analysis should show how the relatively favorable economic development in Central European countries was used in the past decade to develop rail freight transport and how its performance changed. The research is focused on comparing selected indicators of rail freight transport in countries of Central Europe – the Czech Republic, Slovakia, Poland, Austria, and Hungary, obtained from publicly available sources. A relatively simple method that allows an easy and coherent evaluation of traffic performance is benchmarking.

3 BENCHMARKING OF RAILWAY FREIGHT TRANSPORT IN THE CENTRAL EUROPE

Benchmarking can be characterized as a procedure based on the comparison of selected indicators across the compared units and the evaluation of the obtained results. Indicators must be adequately selected and widely respected to be sufficiently informative. Benchmarking results can be effectively implemented in the performance improvement process only if the mentioned rules are respected.

As a research method, benchmarking has been used since about the 1980s. It was initially used to solve more complex tasks requiring international comparison (Hong et al., 2012) or to evaluate existing or future processes and procedures (Joo et al., 2017). It has also found application in assessing the effectiveness and quality of rail freight transport providers' services (Wiegmans et Donders, 2007) or evaluating specific processes in some transport branches (Merkert et al., 2010). Benchmarking can also be used to assess specific key performance indicators in the transport sector, such as service quality, asset utilization, financing, and others (Išoraité 2004). Benchmarking does not give the possibility to obtain mathematically or statistically accurate indicators. However, it accurately determines the investigated indicator's state and development, which is entirely sufficient for this research. This paper will use benchmarking to assess the performance of rail transport within individual states.

The input and output type should be chosen to optimally reflect a specific efficiency indicator. In previous studies, the railway network length, the number of operated railcars or locomotives, the number of dispatched train units or containers, and the number of employees

were frequently used as inputs. The amount of transported goods in tons or tkm, sales, and net profit were usually used as outputs. In some papers, the evaluation of transport performance also included punctuality, the number of train accidents, and customer complaints. The limited amount of input data and their availability, different technical equipment of the railways and different work rules and practices, sustainability, and some other aspects of the investigation were mentioned in previous studies as obstacles for mutual comparison. The various elements of the analysis are presented in the following Table 2.

Tab. 2: Inputs, outputs, and limitations in benchmarking performance measurement

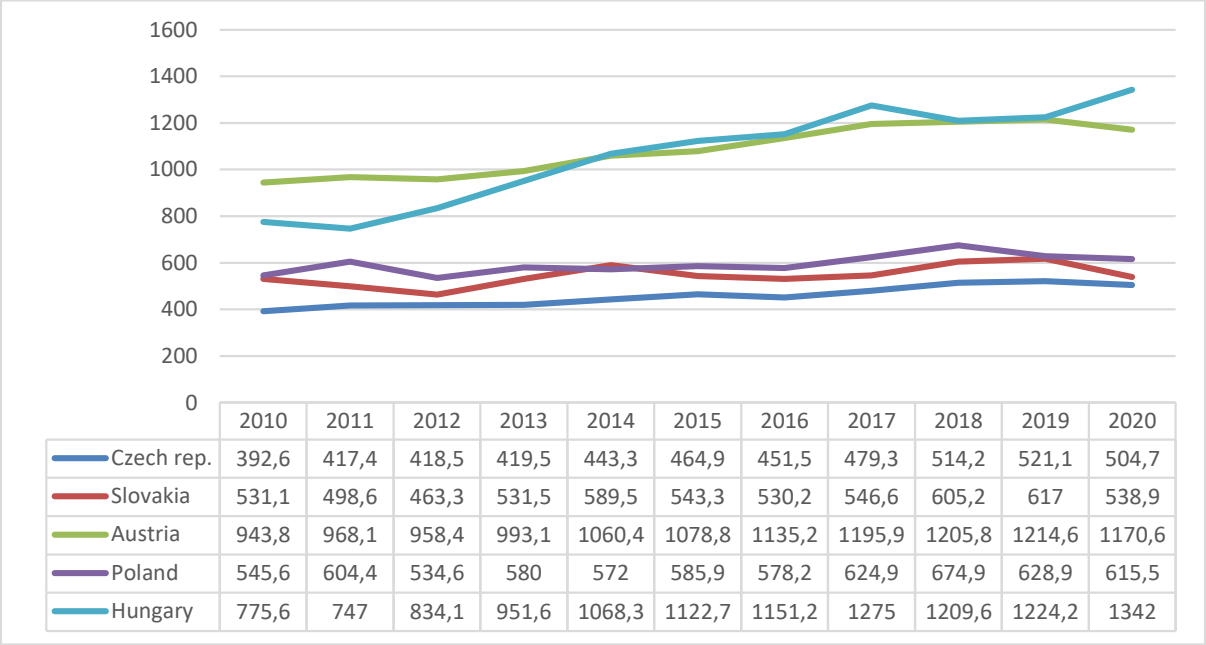
Inputs	**Outputs**	**Limitations**
Number of railcars	Freight in tons	Data availability
Number of locomotives	Freight in tons-km	Various network length
Track lines length	Revenues	Availability of inputs
Number of employees	Punctuality	Technical equipment
Number of TEUs	Customer complaints	Different working culture
Shuttle or unit trains	Train accidents	
	Sustainability	

Source: Modified Wiegmans et Donders, 2007

The analysis is partly inspired by the study of Wiegmans and Donders, uses similar research methods, but focuses on individual states of the Central European region. The paper uses only indicators closely related to rail freight transport: the number of used freight cars and locomotives as inputs and transport performance in tkm as outputs. There is no doubt that transport performance also depends on other factors, such as the length and quality of railway lines, the number and productivity of the workforce, and many others, but access to relevant data from public sources is relatively limited. Therefore, the study only estimates the current situation and the trend of its further development. An analysis of work procedures, rules and practices, technical equipment, and other factors would undoubtedly contribute to a deeper analysis of the problem under investigation, but the relevant data are unavailable.

The effectiveness analysis evaluates indicators related to rail freight transport in Central Europe – the Czech Republic, Slovakia, Poland, Austria, and Hungary. Some countries were deliberately excluded from the evaluation due to their geographical diversity (Croatia, Germany), economic strength, and the focus of their providers' activities (Germany). Benchmarking is based on the evaluation of the transport performance in individual states (expressed in tkm) per unit of input, i.e., wagon (see Fig. 6) or locomotive (see Fig. 7).

Fig. 6: Transport performance in thousands of tkm per rail freight car (wagons)

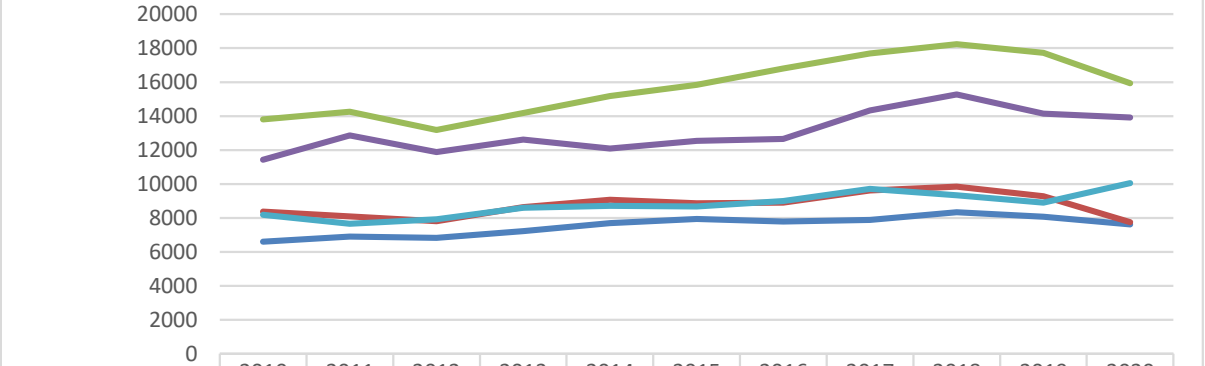


	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czech rep.	392,6	417,4	418,5	419,5	443,3	464,9	451,5	479,3	514,2	521,1	504,7
Slovakia	531,1	498,6	463,3	531,5	589,5	543,3	530,2	546,6	605,2	617	538,9
Austria	943,8	968,1	958,4	993,1	1060,4	1078,8	1135,2	1195,9	1205,8	1214,6	1170,6
Poland	545,6	604,4	534,6	580	572	585,9	578,2	624,9	674,9	628,9	615,5
Hungary	775,6	747	834,1	951,6	1068,3	1122,7	1151,2	1275	1209,6	1224,2	1342

Source: Author - using data from Eurostat 2022

Benchmarking focused on rail freight cars is based on data on their total number regardless of their purpose of use (e.g., covered hoppers, intermodal, tank cars). Data may be influenced in individual countries by the character of industrial production, mineral resources, average transport distance, and other factors. The type of transport services provided should also be considered, e.g., shuttle, mixed, unit, or container train sets. However, data of this kind are not publicly available.

Fig. 7: Transport performance in thousands of tkm per drive unit (locomotive)



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Czech rep.	6604	6896	6833	7228	7691	7948	7798	7882	8331	8073	7629
Slovakia	8382	8098	7802	8632	9074	8864	8904	9622	9851	9285	7756
Austria	13811	14247	13184	14176	15176	15840	16793	17692	18239	17729	15927
Poland	11425	12858	11890	12619	12086	12547	12650	14326	15278	14141	13919
Hungary	8179	7662	7923	8596	8705	8682	8998	9722	9342	8899	10047

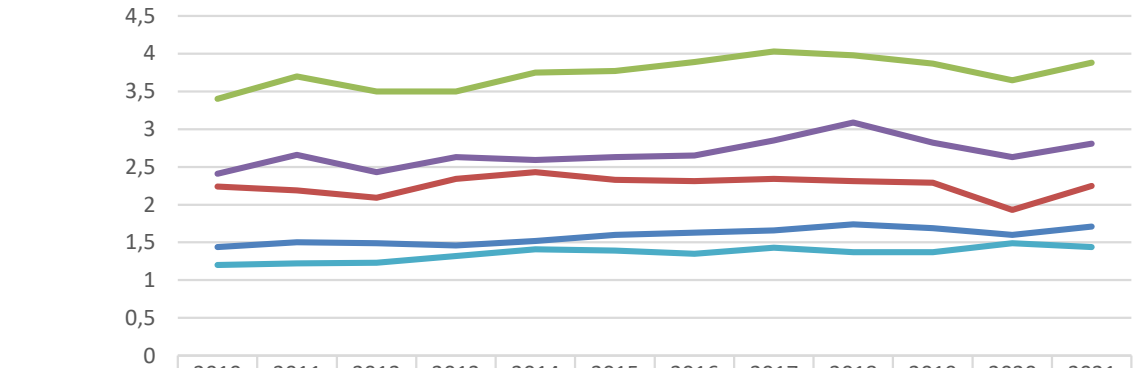
Source: Author - using data from Eurostat 2022

The finding obtained when assessing rail freight vehicles (wagons) performance also partially applies to drive units (locomotives). The operation of locomotives is universal and is not too dependent on the transported good´s nature or transport distance. An important role plays

their technical level, significantly affecting the final transport performance, speed, and reliability of goods transfer.

Comparison of transported tkm/km of lines, the amount of transported goods per unit of distance, i.e. the use of tracks regardless of their quality (single or two-track lines, electrified lines, etc.) Positive results expressed by a high volume of transported cargo in tkm per unit length of track may indicate higher labor productivity but are not necessarily indicators of excellent service quality or acceptable financial results. It is obvious that investments that improve the quality of lines (double-track lines, electrification, traffic safety system) ensure an increase in transport productivity and the achievement of better financial results. The ideal result is the maximum volume of transported goods per unit of distance (see Fig. 8).

Fig. 8: Transport performance in goods transported in tkm per km of lines



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Czech rep.	1,44	1,5	1,49	1,46	1,52	1,6	1,63	1,66	1,74	1,69	1,6	1,71
Slovakia	2,24	2,19	2,09	2,34	2,43	2,33	2,31	2,34	2,31	2,29	1,93	2,25
Austria	3,4	3,7	3,5	3,5	3,75	3,77	3,89	4,03	3,98	3,87	3,65	3,88
Poland	2,41	2,66	2,43	2,63	2,59	2,63	2,65	2,85	3,09	2,82	2,63	2,81
Hungary	1,2	1,22	1,23	1,32	1,41	1,39	1,35	1,43	1,37	1,37	1,49	1,44

Source: Author - using data from Eurostat 2022

It is evident that the assessment should also include other indicators, such as the number and workload of employees, load capacity of lines for passenger transport, and others. However, the mentioned indicators can be analyzed in some further research.

CONCLUSION

The data used to process this study comes mainly from Eurostat, which, unfortunately, does not always provide complete timelines. For this reason, the conclusions in some text passages are formulated only in general terms. In any case, the individual indicators point to visible differences between the results and the development of rail freight transport in the Central European region (see Table 5).

Tab. 5 Comparative indicators - overview of the benchmarking position

Performance:	**Czech rep.**	**Slovakia**	**Austria**	**Poland**	**Hungary**
tkm/railcar (locomotive)	5	4	1→2	3	2→1
tkm/drive unit (wagon)	5	4	1	2	3
tkm transported/km lines	4	3	1	2	5

Source: Author

The results of the benchmarking show that even three decades after the change in the economic and political environment in the countries of the former Eastern Bloc, the limits of the effective functioning of rail freight transport have not been completely removed. Many barriers, such as the lower throughput of the railway network, the outdated traction network, the weaker technical level of the security equipment, the lower professional level of the staff, and others, are being removed very slowly.

A specific problem with the study is that publicly available data from all countries may not always be sufficiently accurate and reliable. Some input data (e.g., the number of power units or railcars) may be distorted by reporting the inventory status, not the number of units used in ordinary operations. However, the indicators reliably show the development of the performance of rail freight transport in the past decade. The benchmarking results suggest that a faster increase in efficiency is necessary and desirable, especially in the new EU countries, and state institutions should play a leading role in this process. State support should be focused mainly on the maintenance and development of the transport network, traffic management, and legislation regulating rail freight transport operating conditions.

The paper has been focused on answering the question: *How has rail freight transport in the Central European region developed under relatively favorable economic conditions in the past decade?* The benchmarking method was used for comparison purposes, and the results were summarized in Table 5.

Based on the vast majority of indicators, it can be said that rail freight transport in Austria achieves the highest efficiency of all the monitored countries significantly. In the case of technical equipment (wagons, locomotives), the performance is roughly twice as high as in other countries, and the difference in the track lines is even higher. In addition, Austria took advantage of the favorable economic situation in the past decade to increase its lead. Operators in Austria particularly benefit from thrifty and environmentally friendly transport services such as the Rolling Motorway, widely used in the country. The local transport operators use systematic state support, which gives them a strong market position and relieves intense foreign competition.

Although the efficiency of rail freight transport in Poland is significantly lower than in Austria, it remains slightly above the level of other Central European countries and is gradually increasing. The longer average transport distance and the more intensive use of container and unit trains influence the positive results. Poland's results are undoubtedly affected by roughly a quarter of freight transport performance (especially the more profitable one) provided by a technically well-equipped German carrier. The development of the performance of Polish rail freight transport over the last decade can be assessed as slightly positive, despite the crisis in Ukraine in 2014, which negatively affected transit transport.

The position of both countries, the Czech Republic and Slovakia are very similar in benchmarking rail freight services. Progress in the efficiency of transport services is minimal in both cases. In addition, it can be expected that the past epidemic and the upcoming energy crisis will slow down or completely stop positive development.

The performance assessment of railway freight services in Hungary shows noticeable progress, especially in comparing technical means (railway wagons). The development to this date can be explained by the fact that many essential services are provided by the efficiently functioning local branch of Rail Cargo Austria. A comparison of the indicators of transported volume in tkm per unit of track length shows a significant (more than double) lead for Austria. Somewhat surprising is the relatively acceptable position of Poland and Slovakia; lagging is evident in the case of the Czech Republic and Hungary. Over the past decade, the situation has not changed significantly.

The paper shows some differences in the efficiency of rail freight transport in the countries of the Central European region. The efficiency level in the Czech Republic, Slovakia, and Poland are still significantly behind Austria, and this gap is widening. The past decade, relatively favorable for doing international rail freight transport business, unfortunately, did not bring any significant changes (with the partial exception of Hungary). Benchmarking, as a method used in this paper, confirms the stated situation and indicates the trend of its further development.

The future development of rail freight transport in the EU, including the Central European region, is outlined in the so-called EU "White paper" from 2010. This Regulation lays down rules for the organization and management of European rail transport with a view to the development of a rail network for competitive freight. At the same time, it sets the rules for the selection, investment planning, and implementation of railway network development. However, implementing the adopted Regulation largely depends on the available resources. The ongoing pandemic, the protracted European energy crisis, and the uncertain geopolitical situation do not make it possible to accurately and reliably predict future development. Future research on rail freight transport is thus largely dependent on the existence of a more stable and predictable economic environment.

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