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THE LAST MILE CONCEPT FOR THE BYDGOSZCZ LOGISTICS HUB

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Abstract

Purpose: The purpose of this article is to discuss the last mile concept for the proposed Bydgoszcz Logistics Hub in the Kujawsko-Pomorskie region, and thus to present the forecast distribution of goods within the last mile from and to the Hub, and to indicate the role that it could play in the region.

Method: The development of the last mile concept for the Bydgoszcz Logistics Hub was based on secondary data. The first two stages of work, not discussed in this article, included case studies of 6 successfully operating foreign and domestic transhipment terminals and an analysis of the supply and demand for transport in the Kujawsko-Pomorskie Voivodeship. The third stage, the results of which are presented in this article, involved the identification of the most important national centres generating supply and demand for transport within a radius of 280 km from the Hub. Data, allowing to estimate the potential demand for the fright transport on the analysed routes and their costs depending on the mode of transport, came mainly from the Central Statistical Office, the Railway Transport Office, the General Board of National Roads, the National Bank of Poland and Port of Gdynia and Gdańsk Authorities.

Results: The data show that in the period covered by the forecast (2019-2034), the most important change in the transport model of the Hub service area will be a significant increase in inland waterways transport of the Vistula River.

Conclusions: The forecast operation of the last mile for the Bydgoszcz Logistics Hub justifies the reloading, storage and forwarding of goods in the area of the Bydgoszcz-Toruń agglomeration. The construction of the Bydgoszcz Logistic Hub will bring improvement to the already existing road links leading to the most important logistic centres, located, on the one hand, in the Tricity seaports, on the other hand, in large economic centres in Poznań, Łódź and Warsaw.

Keywords: Baltic Sea Region, combine transport, logistics hub, last mile

Paper type: Research paper

1. Introduction

The forecasts for 2050 predict a fourfold increase in the turnover of seaports worldwide (Transport Outlook 2015). Therefore, Polish seaports such as Gdańsk and Gdynia, expecting a significant increase in transhipments, invest in their infrastructure and equipment (build new terminals and deepen ports) in order to be able to compete effectively for this increased demand (Wojewódzka-Król and Rolbiecki, 2017). However, this may not be enough as hinterland transport connectivity is the second most important factor behind port competitiveness, after port costs (Sdoukopoulos and Boile, 2020). It is gaining more and more importance with the development of intermodal and combine transport systems, which include ports. Port hinterland presents the geographical area to and from which cargo passing through the port can be distributed (Shi and Li, 2016). Its connectivity determines the port efficiency as the bottleneck of intermodal transportation systems has shifted from the ship/port interface to the port/inland interface (Heaver 2006, via Wan *et al.*, 2014). The efficiency of transport in the hinterland is an important factor affecting costs and safety in transport. Therefore, ports that are insufficiently linked to the hinterland lose some cargo to ports with better connections to the hinterland (Wojewódzka-Król and Rolbiecki, 2017). Unfortunately, this may be the case with the ports of Gdańsk and Gdynia, which urgently require increasing the infrastructural potential of their hinterland.

Currently, only road and rail transport is involved in servicing the hinterland of the ports of Gdańsk and Gdynia (Wojewódzka-Król and Rolbiecki, 2017), while the basis of intermodal freight transport chains are rail and barge services (de Langen *et al.*, 2017). Due to the current load on the road and rail transport infrastructure around the ports of Gdańsk and Gdynia, these modes of transport already have problems with ensuring an appropriate standard of services. In the conditions of the fulfilment of forecasts of transhipments in ports, they may become inefficient. There are serious concerns that road and rail transport will not be able to competitively meet the anticipated demand for transport in relations with seaports at the mouth of the Vistula River (Wojewódzka-Król and Rolbiecki, 2017). It is, therefore, essential that the port area is integrated with an efficient inland distribution system that encompasses inland waterways, rail and road transport (Czermański, 2021). Such a system needs to be built, next to seaports, on inland platforms and terminals which also play an essential role for the efficient application of intermodal and combined transport (Czermański, 2021). Combined transport, according to UNECE (2001), is defined as intermodal transport in which most of the European journey is made by rail, inland waterway or sea, and all initial and/or final stages by road are as short as possible. In turn, intermodal transport is defined as the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes (UNECE,

2001). Inland platforms and terminals are thus transhipment facilities where cargo units can be moved between two or more different modes of transport that are not located directly on the coast but inland.

Today, freight transport is one of the biggest greenhouse gas contributors, responsible for around 25% of the European Union's emissions. Therefore, the concept of combined transport is currently strongly advocated by the European Commission due to the promising effects of its implementation for the climate challenge facing Europe. According to the European Green Deal, the European Commission's plan is to meet 55% emission reduction by 2030, which will be the first step of the carbon neutrality set for 2050 (EC, 2021). It is expected that the combination of the concept of intermodal transport – which is based on the use of containers, semi-trailers and swap bodies – with the concept of combined transport – based on the predominant use of rail, inland waterway or sea transport, and only to a small extent, within the first/last mile of road transport – will generate not only benefits in terms of lowering transport costs, but also reducing harmful emissions. Therefore, large European seaports, forecasting changes in turnover, are also planning to change the hinterland transport structure to a more environmentally friendly one. For example, the port of Rotterdam plans to increase the share of inland waterway transport to 45% by 2035, and rail transport to 20%, while the port of Hamburg assumes an increase in rail transport to 45% in 2030 and a dozen or so percent share of inland waterway transport (Wojewódzka-Król and Rolbiecki, 2017). European trends of changes in ports and in the hinterland are in line with the policy of sustainable transport development in Europe and should set the directions of changes in Poland. The use of inland waterway transport in the hinterland of the seaports of Gdańsk and Gdynia would allow for many benefits, such as reduction of effective transport costs, accidents related to the improvement of road safety, environmental degradation and road maintenance costs by reducing the pace of their destruction (Wojewódzka-Król and Rolbiecki, 2017).

Therefore, this article presents selected results of the Combine project, in which nearly 30 partners and affiliated organizations from ten countries in the Baltic Sea Region developed strategies and launched promotional campaigns to strengthen combined transport in the region. These activities were carried out with the support of the Interreg Baltic Sea Region Program and various stakeholders from the Baltic Sea Region. One of them was the Kujawsko-Pomorskie Voivodeship Self-government, which, together with its partners, the Nicolaus Copernicus University in Toruń and the University of Gdańsk, and with the participation of Infra - Centrum Doradztwa Sp. z o.o. from Warsaw, developed a document entitled "The last mile concept for the Bydgoszcz Logistics Hub," the content of which was used in this article. The purpose of this article is to discuss this concept, and thus to present the forecast distribution of goods within the last

mile (i.e. within a radius of approx. 280 km from the logistics centre) from and to the Bydgoszcz Logistics Hub, and to indicate the role that it could play in the region.

2. The Bydgoszcz Logistics Hub

The Bydgoszcz Logistics Hub is an investment, prepared by the Kujawsko-Pomorskie Voivodeship Self-government, whose main objective is to exploit the potential of the Kujawsko-Pomorskie Voivodeship for the development of transport and logistics services. It is conveniently located in terms of the most important national transport routes, as well as the Baltic-Adriatic Transport Corridor. Presently, the Kujawsko-Pomorskie region does not possess any transhipment platform that would offer comprehensive freight logistics services, nevertheless, the storage space and the percentage of land allocated to the investment has been increasing for many years now.

The Bydgoszcz Logistics Hub is an undertaking comprising of two scheduled investments in the realm of multimodal transport and development of logistics-storage centre networks, i.e. the Bydgoszcz-Solec Kujawski Multimodal Platform (based primarily on the inland port on the Vistula River) and the Bydgoszcz Emilianowo Intermodal Terminal. The platform is to play the role of a regional logistics-storage centre situated at the intersection of freight trails of high potential, i.e. E40 and E70 international waterways, nearby railway routes

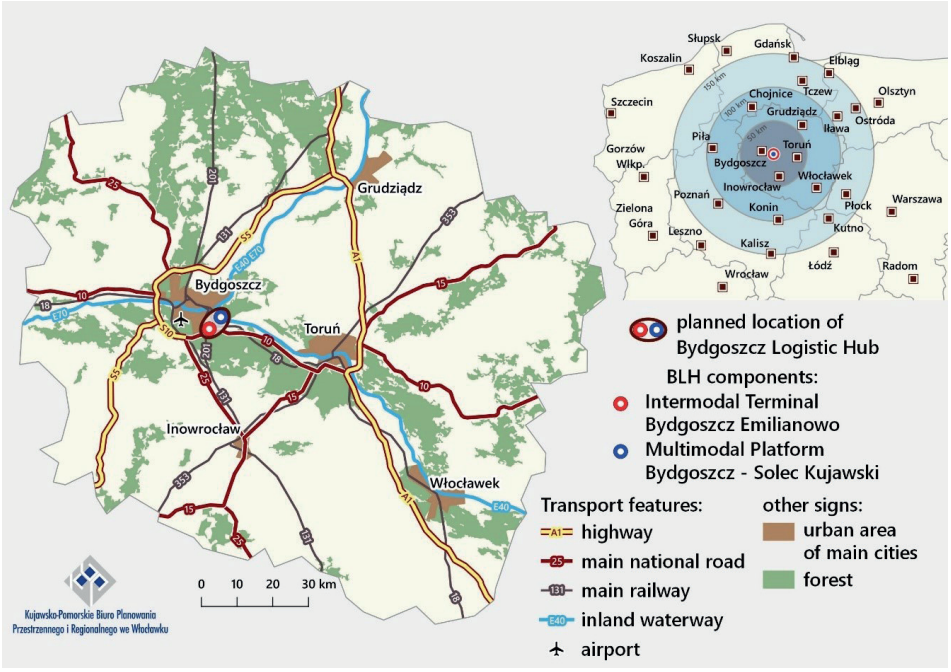

Figure 1. Location of the Bydgoszcz Logistics Hub in the region

Source: Office for Spatial and Regional Planning in Włocławek.

nos. 18,131 and 201, A1 motorway, S10 and S5 express roads as well as in the vicinity of large urban areas, such as Toruń and Bydgoszcz. Consequently, the Terminal will provide interfaces for cargo shipped from the seaports of Gdańsk and Gdynia by rail, thereby improving national transport system. The realisation of the investment of the Terminal is scheduled for 2024, and the Platform for 2028. Figure 1 shows the location of the Bydgoszcz Logistics Hub in the region.

3. Last mile - theoretical perspective

Gevaers *et al.* (2014) denoted last mile as "the last part of the supply chain". The last mile does not literally mean the last single mile in the process of delivering goods, only the last step of distribution along the supply chain. Thus, the last mile is the movement of goods between a transport hub and a delivery address. In combined transport, multimodal platforms and intermodal terminals are natural logistic hubs where cargo is exchanged between vehicles and/or between transport modes. The last mile range for this type of logistics hubs is determined by their geographical service area. It is recommended that the maximum size of the terminal service area equals the distance covered by trucks in 90 minutes (Czermański, 2021). Other authors suggest a distance of 100 to 300 km, and therefore, one where road transport, which mostly serves the last mile, is faster and more flexible than any other mode of transport (see, for example, Carboni *et al.*, 2018).

The last mile becomes the first mile when analysed in the context of pickup operations instead of deliveries in an urban distribution system (Bergmann *et al.* 2020). In comparison to the first leg of the supply chain, which has low frequency and high capacity, last mile delivery has a high frequency and low capacity (Rodrigue, 2013). Last mile delivery is critical to the efficiency of supply chain and logistics management, as the share of its volume is systematically growing in all transportation within the supply chain (Ewedairo *et al.*, 2018). It is common knowledge that last mile distribution is the most polluting, most costly, and inefficient aspect of municipal logistics (Ji *et al.*, 2019). Therefore, great emphasis is placed on the development of strategies to reduce these negative externalities in last mile logistics (Digiesi *et al.*, 2017).

Last mile surveys are usually carried out either from the perspective of the city or urban area (Gevaers *et al.*, 2014) or the logistics hub or logistics service provider (LSP) that serves it (Nathanail *et al.*, 2016, de Langen *et al.*, 2009). They cover a variety of topics such as processes and activities within a city (Gevaers *et al.*, 2014), strategies of logistics hubs (de Langen *et al.*, 2009), the mode of delivery (Aized and Srai, 2014) and distances covered (Ehmke, 2012), including B2C and B2B deliveries (Ewedairo *et al.*, 2018).

This article presents the perspective of logistic centres that participate in multimodal logistic chains, especially in the hinterland of seaports, such as river

ports, which act as multimodal platforms, or intermodal terminals, combining road transport with rail and/or inland waterway transport. As terminal distribution is of key importance due to its responsibility for the final delivery of logistics activities, these logistics operators should create comprehensive last mile strategies, thanks to which they will be able to maintain a high level of customer satisfaction and reduce delivery costs to a minimum. This is particularly significant as terminal distribution is the least efficient stage in the supply chain accounting for 28% of the total cost of delivery (Aized and Srai, 2014). Also, the preparation of infrastructure investments leading to the construction of logistic hubs should be preceded by the development of a reliable forecast of the demand for intermodal transport services (Czermański, 2021).

4. Research approach

The last mile for the Bydgoszcz Logistics Hub is perceived as the last stage of the supply chain which allows for the delivery of goods from the logistic centre at the Hub to the end-customer, i.e. a client, shop or pick up centre located within 80-280 km by using freight transport vehicles.

The development of the last mile concept for the Bydgoszcz Logistics Hub was based on secondary data. Primarily, in order to get a full comprehension of the proper functioning of the last mile in successfully operating centres and transhipment terminals, the analysis focused on available data concerning 6 establishments, similar to the planned ones. Three of them are located abroad: The Westhafen Terminal in Berlin, The Lille-Dourges Container Terminal and The Gothenburg Terminal, and the other three operate in Poland: the Silesian Logistics Centre in Gliwice, the Poznań Logistics and Investment Centre in Swarzędz and the Intermodal Terminal in Brzeg Dolny. They were recognised as benchmarks and case study subjects for the analysis.

Subsequently, technical aspects connected with the transhipment and distribution of goods at the Bydgoszcz Logistics Hub as well as the cost generated at each stage of the supply chain were all taken into consideration. The abovementioned stage involved identification of the most important demand and supply generating centres in the Kujawsko-Pomorskie Voivodeship and in the country, as well as the biggest businesses and enterprises that would become potential stakeholders for the Hub.

Furthermore, there was an analysis carried out, which revealed an estimated operation cost of road transport in selected stretches related to the average daily traffic by GTM (General Traffic Measurement) from 2015 and later referred to 2019 with the use of GDP indicator issued by the General Board of National Roads, modified by the elasticity coefficient. As for the freight and road performance, they were based on the Central Statistical Office (GUS) data. The estimates concerning the amount of cargo and goods were based on the Railway

Transport Office (UTK) statistics and the Centre for EU Transport Projects (CUPT) publication: "Cost-benefit Analysis of Transport projects co-financed by the EU: The Beneficiary's Vademecum, 2016". The results for the Lower Vistula River were provided mainly by the current and back data issued by the Central Statistical Office (GUS).

The data taken from the strategic and project documents obtained from the Port of Gdynia and Gdańsk Authorities, updated with the current GDP short-term forecast, the information on national demand for fuel: "Forecast for the national demand for the capacity of the current and emergency gas and oil stock for 10 year period (2020-2029)", issued by the Agency of Material Reserves, forecasts of national energy and fuel gross consumption, the Ministry of Energy's publication: "Conclusions from Prognostic Analysis for the Fuel and Energy Sector, 2019" served as the basis for the development of the growth pattern in the volume of the transhipped cargo.

Apart from the foreseen increase in cargo transhipment at the seaports of Gdynia and Gdańsk, the forecast encompassed other determinants affecting the volume of the transhipped goods. Cargo road transport on the selected routes between Gdańsk, Gdynia, Warsaw, Łódź, Poznań and Kujawsko-Pomorskie Voivodeship was estimated on the basis of "General Traffic Demand Forecast, 2015", updated with the General Board of National Roads (GDDKiA) GDP forecast and modified with the use of the current data and the short-term GDP forecast published by the National Bank of Poland, as well as the data pertaining to cargo transport and its structure from the Central Statistical Office.

Estimates for cargo railway transport were based on the Statistics on Rail Traffic Volume (SOLK), The Office of Rail Transport (UTK) and Central Statistical Office (GUS) data with the consideration of the information included in the "Sustainable Transport Development Strategy until 2030", updated with the current and short-term estimates of transport forecasts based on the GDP projections issued by the National Bank of Poland. Extrapolation of the freight work for the Lower Vistula River was drawn up on the basis of the current and back data issued by the Central Statistical Office, Eurostat and the report "The Use of Inland Waterway Transport in Poland, 2018", issued by the Polish Chamber for Forwarding and Logistics.

The analysis of unit freight work was calculated at fixed prices for 2020 with regard to PLN rates. The cost analysis for railway transport from Gdańsk/Gdynia to the Bydgoszcz Logistic Hub was based on the market research, data available from various business resources and the tools provided by Kalkulacja PKP site at average prices based on the cost categories including: the forwarding service, unit cost of the railway transport and transhipment at the terminal. The calculations encompassed: gross train weight of 1500 tonnes, net/gross train weight conversion - 0,45, an average cargo weight - 675 tonnes and an average conversion rate

for TEU (20-foot containers) - 12. The cost analysis for the road transport was calculated analogically to the railway one (obviously, excluding Kalkulacja PKP site, but with the consideration of the unit freight work, motorway toll and dedicated transhipment cost at the terminal). The calculations encompassed the track tractor semi-trailer payload of 24 tonnes, toll - PLN 0,38/km and the average TEU conversion factor - 12. Customs service and indirect taxes were excluded, though.

The cost of inland waterways transport was calculated analogically. Regrettably, data publications necessary to establish the values were scarce and thus they had to be based on a widely available national and foreign market data obtained from carriers. The calculations were based on the TEU/t conversion rate of 12.

The article presents only part of the results, namely freight transport demand generated by the most important centres in the country within 280 km from the Hub and freight shipment cost of selected modes of transport.

5. Analysis results

5.1. Demand for freight transport

The analyses produced data concerning freight on selected routes in 2019, as follows:

a) road transport
- Bydgoszcz – Pruszcz Gdański (national road no. 5/S5 – express road, A1 – motorway) – Gdańsk/Gdynia (S6/S7 – express roads) – **71 m** tonnes of freight,
- Bydgoszcz – Poznań (national road no.5/S5– express road) – **47 m** tonnes of freight,
- Bydgoszcz – Toruń (national road no. 10) – Łódź (A1 – motorway) – Warsaw (A2 – motorway) – **75 m** tonnes of freight;

b) railway transport
- Bydgoszcz – Gdańsk (RL nos. 131, 226)/Gdynia (RL no. 201) – **12,8 m** tonnes of freight,
- Bydgoszcz – Poznań (RL nos. 131, 353) – **4,9 m** tonnes of freight,
- Bydgoszcz – Toruń (RL no. 18) – Łódź (RL nos. 3, 16, 131, 544) – Warsaw (RL nos. 3, 18, 07) – **11,6 m** tonnes of freight.

Freight transport on the analysed routes in 2019 is shown in Figure 2.

The last to be analysed was the inland waterways transport system, as it is of marginal significance to the cargo handling operations. The total freight carried in the Lower Vistula River in 2019 amounted to 71000 tonnes of bulk transport, which translates into 290 000 of tonne-kilometre of payload. According to the estimates for the aforementioned routes, the total payload in 2019 amounted to

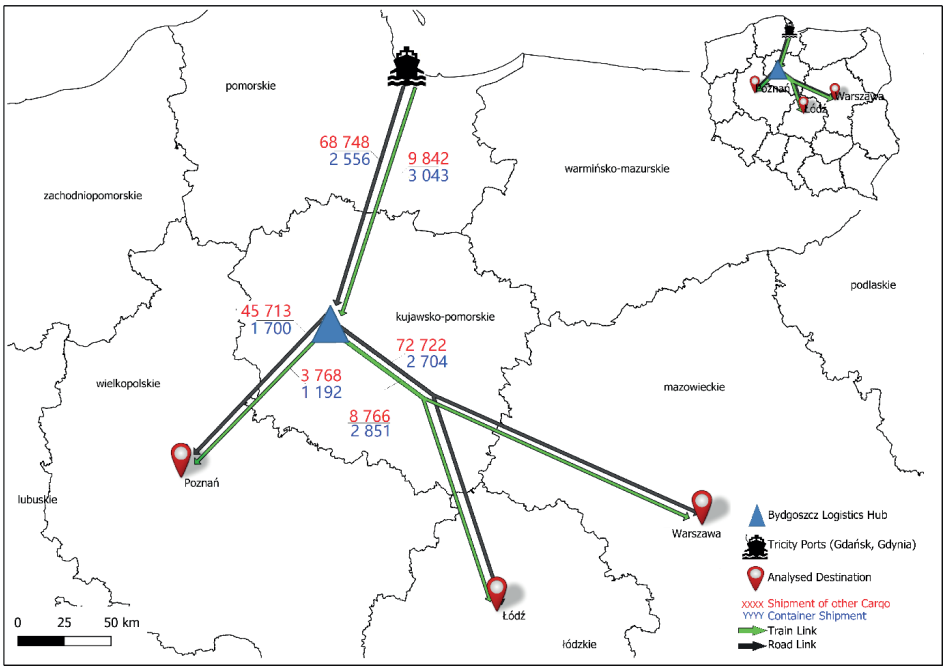

Figure 2. Freight shipment on selected routes in 2019 in tonne-kilometres

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

36 197 m tonne-kilometre. 80% of the payload was performed by road, 19% by rail, and inland waterways transport was only incidentally used for the shipment of oversize goods.

According to the forecast results shown in Table 1, over 94 m tonnes will have been transhipped by 2025, and 130 m tonnes of freight in both ports, in total, by 2034. At the rate of 76m tonnes transhipped in 2019, the volume will have risen by 71% in the projected period. The share of the containerised cargo will have risen from 49% in 2019 to 69% by 2034.

Table 1. Forecast of transhipments for the seaports of Gdańsk and Gdynia 2019–2034 (thousand tonnes)

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

	2019	2020	2025	2030	2034
Gdańsk					
Bulk cargo	29 263	25 696	27 990	28 426	28 353
Containers	22 891	22 129	31 000	43 765	57 313
total	**52 154**	**47 826**	**58 990**	**72 191**	**85 666**
Gdynia					
Bulk cargo	9 817	10 735	11 386	12 159	12 649
Containers	14 148	13 677	24 456	28 960	32 060
total	**23 965**	**24 412**	**35 842**	**41 119**	**44 709**

Another study revealed the forecast of growth pattern of freight transport from the Hub to sensitive destinations. Extrapolation of the results indicated that in 2034 the freight on selected routes will be as follows:

c) road transport

- Bydgoszcz – Pruszcz Gdański (national road no. 5/S5– express road, A1 – motorway) – Gdańsk/Gdynia (S6/S7 – express roads) – **96 m** tonnes of freight,
- Bydgoszcz – Poznań (national road no. 5/S5 – express road) – **66 m** tonnes of freight,
- Bydgoszcz – Toruń (national road no.10) – Łódź (A1 – motorway) – Warsaw (A2 – motorway) – **102 m** tonnes of freight;

d) railway transport

- Bydgoszcz – Gdańsk (RL nos. 9, 131, 226)/Gdynia (RL no. 201) – **15,3 m** tonnes of freight,
- Bydgoszcz – Poznań (RL nos. 131, 353) – **6 m** tonnes of freight,
- Bydgoszcz – Toruń (RL no. 18) – Łódź (RL nos. 3, 16, 131, 544) – Warsaw (RL nos. 3, 18, 07) – **13,7 m** tonnes of freight.

The foreseen freight transport on the analysed routes in 2034 is shown in Figure 3. The most significant change in the transport model shows a dramatic increase in the volume of inland waterway transport system on the Vistula river.

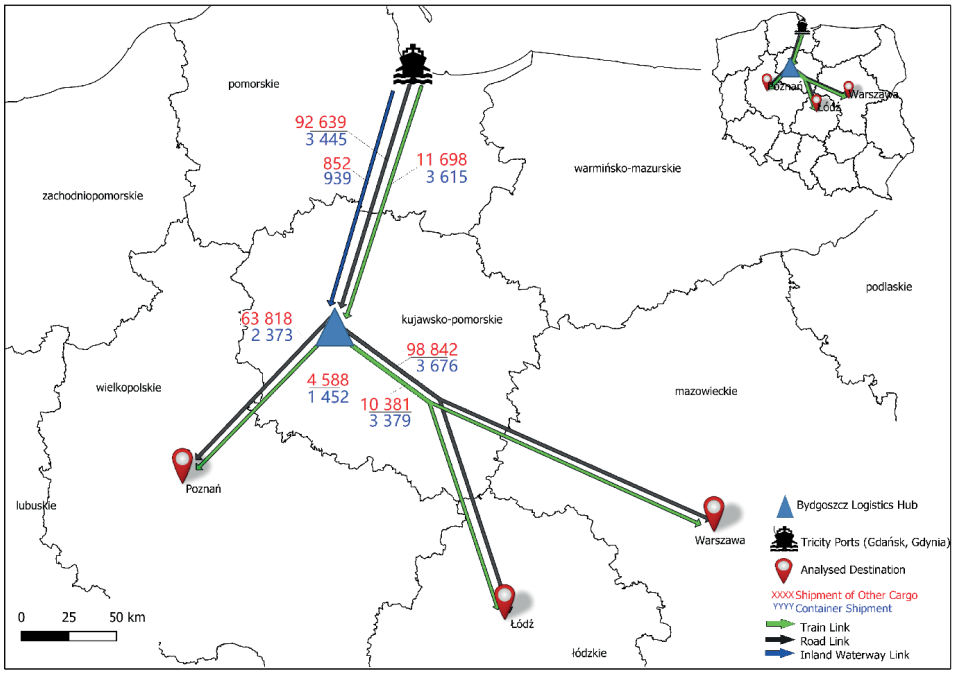

Figure 3. Freight shipment on selected routes in 2034 in tonne-kilometres

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

In the assumed time span until 2034 the routes will not be of international significance yet, (the projected navigability class IV, enabling the navigation of the largest transport vessels, whilst extending the navigation season to 292 days will be possible after 2045). Nevertheless, the works aiming at improvement and modernisation of the waterways will be commenced and performed to ensure at least navigability class III. Simultaneously, the fleet enabling the cargo transport from/to the port of Gdynia and Gdańsk will be upgraded.

Extrapolation of the payload results for the Lower Vistula River indicated that 6,6 m tonnes of freight will have been transported by the end of 2034. It is projected that the payload in tonne per kilometre will have increased by 37% in total. Invariably, the road transport, whose share amounts to 81%, remains the leading shipment mode, whereas the largest increase can be observed in the inland waterways transport, whose share rose to 2,7%, at the cost of the railway transport, in total.

5.2. Cost of freight shipment

Future attractiveness of the Bydgoszcz Logistic Hub lies in its accessibility to the inland waterways transport. The concept of the last mile includes the analyses of both, unit cost for cargo transport for all modes from the seaports of Gdańsk and Gdynia to the Bydgoszcz Logistic Hub and then to the end-customer in Warsaw, Łódź and Poznań, and the cost of cargo transhipment at the Hub. The analyses are shown in Table 2.

From/to	Cost of cargo transport per unit – other cargo	Cost of cargo transport per unit – intermodal transport
Rail transport		
Port of Gdańsk – Emilianowo	0,0786 PLN/tkm	0,0776 PLN/tkm
Port of Gdynia – Emilianowo	0,0755 PLN/tkm	0,0745 PLN/tkm
Port of Gdańsk – Solec Kujawski	0,0797 PLN/tkm	0,0788 PLN/tkm
Port of Gdynia – Solec Kujawski	0,0770 PLN/tkm	0,0761 PLN/tkm
Road transport		
Port of Gdańsk – Emilianowo	0,1319 PLN/tkm	0,1248 PLN/tkm
Port of Gdynia – Emilianowo	0,1205 PLN/tkm	0,1140 PLN/tkm
Port of Gdańsk – Solec Kujawski	0,1377 PLN/tkm	0,1302 PLN/tkm
Port of Gdynia – Solec Kujawski	0,1259 PLN/tkm	0,1191 PLN/tkm
Waterways transport		
Port of Gdańsk – Solec Kujawski	0,0391 PLN/tkm	0,0370PLN/tkm
Port of Gdynia – Solec Kujawski	0,0351 PLN/tkm	0,0332PLN/tkm

Table 2. Freight cost per unit shipped from Gdańsk/Gdynia to the Bydgoszcz Logistic Hub

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

Another element subject to analysis was the cost of cargo discharge from trains, trucks and barges at the crossdocking area and loading onto trucks/vans and trains to the stakeholders in Warsaw, Łódź and Poznań. The result of the estimates enabled a wide variety of calculations, which indicated the cost of discharge from:

- the barge- 9,576 PLN/tonne for containers and 10,520PLN/ tonne for other cargo;
- the truck respectively -8,021 PLN/tonne and 9,631 PLN/tonne;
- the train respectively–11,606 PLN/tonne and 12,500 PLN/tonne.

Loading at the last stage of the supply chain was as follows: loading onto a van – 9,631 PLN/tonne; a truck – 8,021 PLN/tonne for containers, and 9,631PLN/ tonne for other type of cargo; a train- 11,606 PLN/tonne for containers and 12,500 PLN/tonne for other types.

The last stage of the analysis included cost estimates at the final stage of the supply chain, which is when the goods are delivered to the end-recipient. The assumed end customers are located in three most important urban centres, in the hinterland, i.e. Poznań, Łódź, Warsaw. The data is shown in Table 3 and 4.

From/to	Cost of transport by light commercial vehicle (LCV)
Emilianowo – Warszawa	0,826 PLN/tkm
Emilianowo – Łódź	0,963 PLN/tkm
Emilianowo – Poznań	1,183 PLN/tkm
Solec Kujawski – Warszawa	0,830 PLN/tkm
Solec Kujawski – Łódź	0,963 PLN/tkm
Solec Kujawski – Poznań	1,136 PLN/tkm

Table 3. Cost of cargo shipment by LCV between the Bydgoszcz Logistics Hub and Łodź, Poznań and Warsaw

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

From/to	Cost of transport by truck – containers	Cost of transport by truck – other cargo	Cost of transport by train – containers	Cost of transport by train other cargo
Emilianowo – Warszawa	0,0915 PLN/tkm	0,0967 PLN/tkm	0,0695 PLN/tkm	0,0704 PLN/tkm
Emilianowo – Łódź	0,1124 PLN/tkm	0,1188 PLN/tkm	0,0713 PLN/tkm	0,0722 PLN/tkm
Emilianow – Poznań	0,1694 PLN/tkm	0,1853 PLN/tkm	0,0882 PLN/tkm	0,0892 PLN/tkm
Solec Kujawski – Warszawa	0,0922 PLN/tkm	0,0975 PLN/tkm	0,0689 PLN/tkm	0,0699 PLN/tkm
Solec Kujawski – Łódź	0,1124 PLN/tkm	0,1188 PLN/tkm	0,0707 PLN/tkm	0,0717 PLN/tkm
Solec Kujawski – Poznań	0,1651 PLN/tkm	0,1745 PLN/tkm	0,0879 PLN/tkm	0,0889 PLN/tkm

Table 4. Cost of cargo shipment by truck/train from the Bydgoszcz Logistics Hub to Łódź, Poznań and Warsaw

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

The data allowed to calculate the cost of cargo shipment from the seaport of Gdańsk/Gdynia to the end-customer in Poznań/Łódź/Warsaw in the supply chain provided by the Bydgoszcz Logistic Hub, as presented in Table 5 and 6.

Distance	Intermodal transport– containers(PLN/t)			Freight transport – other types (PLN/t)		
	Road transport	Rail transport	Inland waterways transport	Road transport	Rail transport	Inland waterways transport
Port of Gdańsk – Emilianowo – Warszawa	270,653	264,104	ND	273,615	265,164	ND
Port of Gdańsk – Emilianowo – Łódź	250,377	243,828	ND	287,961	244,887	ND
Port of Gdańsk – Emilianowo – Poznań	231,849	225,299	ND	269,432	226,359	ND
Port of Gdańsk – Solec Kujawski – Warszawa	269,954	263,103	254,713	272,916	264,156	256,050
Port of Gdańsk – Solec Kujawski – Łódź	250,377	243,526	235,136	253,339	244,579	236,473
Port of Gdańsk – Solec Kujawski – Poznań	234,995	228,144	219,754	237,957	229,197	221,091
Port of Gdynia – Emilianowo – Warszawa	270,653	265,142	ND	273,615	265,734	ND
Port of Gdynia – Emilianowo – Łódź	250,377	244,866	ND	253,339	245,457	ND
Port of Gdynia – Emilianowo – Poznań	231,849	226,338	ND	234,811	226,929	ND
Port of Gdańsk – Solec Kujawski – Warszawa	269,954	264,255	254,713	274,049	265,328	255,301
Port Gdańsk – Solec Kujawski – Łódź	250,377	244,678	234,827	254,472	245,751	235,724
Port Gdańsk – Solec Kujawski – Poznań	234,995	229,296	219,445	239,090	230,369	220,342

Table 5. Summary of transport cost per unit from the seaports of Gdańsk and Gdynia to the end-recipient in Łódź, Warsaw and Bydgoszcz (by light delivery vehicle from the Hub)

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

The calculations included in Table 5 and 6 clearly indicate that the lowest cost of cargo shipment covers a combination of inland waterways transport from the seaports to the Hub and then by train to the end-recipient for both, the containers and other types of freight. As for the supply chain route from the seaport to the Bydgoszcz Logistic Hub and then to the end-customer located in the Kujawsko-

Pomorskie region and the neighbouring counties, the best option is by inland waterways transport system from the seaports to The Bydgoszcz Logistic Hub, and then by road, using commercial vehicles for carrying containers or other types of cargo. Obviously, it is strictly dependent on the capacity and efficiency of the inland waterways transport and the extent of realisation of the projected investment in the Lower Vistula River. Nevertheless, such a combination of transport modes will become a competitive advantage for the Hub over other logistic and warehousing centres lacking inland waterways transport connection.

Distance	Intermodal transport– containers(PLN/t)			Freight transport – other types (PLN/t)		
	Road transport	Rail transport	Inland waterways transport	Road transport	Rail transport	Inland waterways transport
Port of Gdańsk – Emilianowo – Warszawa	80,421	73,871	ND	84,734	76,282	ND
Port of Gdańsk – Emilianowo – Łódź	79,299	72,750	ND	83,548	75,096	ND
Port of Gdańsk – Emilianowo – Poznań	81,793	75,244	ND	87,108	78,656	ND
Port of Gdańsk – Solec Kujawski – Warszawa	81,772	74,921	66,531	84,734	75,974	68,495
Port of Gdańsk – Solec Kujawski – Łódź	79,299	72,447	64,057	83,548	74,788	67,309
Port of Gdańsk – Solec Kujawski – Poznań	81,793	74,942	66,552	87,075	78,314	70,835
Port of Gdynia – Emilianowo – Warszawa	79,299	74,910	ND	83,548	76,852	ND
Port of Gdynia – Emilianowo – Łódź	78,177	73,788	ND	82,362	75,666	ND
Port of Gdynia – Emilianowo – Poznań	80,671	76,282	ND	85,922	79,226	ND
Port of Gdańsk – Solec Kujawski – Warszawa	80,650	76,073	66,330	83,548	77,146	67,681
Port of Gdańsk – Solec Kujawski – Łódź	78,177	73,599	63,857	82,362	75,960	66,495
Port of Gdańsk – Solec Kujawski – Poznań	80,671	76,094	66,351	85,889	79,486	70,021

Table 6. Summary of cargo shipment cost per unit from the seaport of Gdańsk and Gdynia to the end–customer in Łódź, Warsaw and Bydgoszcz (with use of trucks from the Hub)

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

It is also necessary to show average lead times for cargo shipment on the analysed routes (see Figure 4). The analysis shows that an average transport lead time from the seaport to the Hub is 3 h, by rail over 5 hours, and by inland waterways system-over 19 h. Nonetheless, it must be noted that not all goods require express delivery to the end-customer or are subdued to the time pressure (in case they are, the fastest form of delivery is by road), and the development of container shipment services allows carrying all types of goods (including liquids and temperature–sensitive goods). All things considered, also environmental aspects are of paramount importance to the Concept. Motor barges or pusher tugs with barges emit fivefold less carbon dioxide than commercial vehicles and significantly less sulphur and nitrogen compounds. To some extent, the waterways inland transport allows lowering the cost of road shipment, as it reduces traffic congestion and accident occurrence on roads.

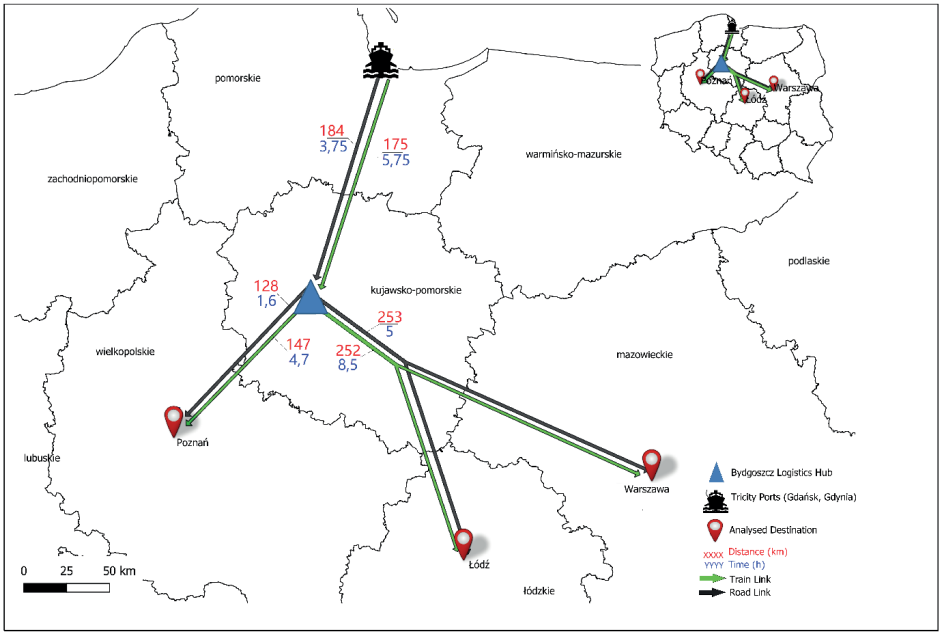

Figure 4. Average transport lead time and distance for cargo shipped on the analysed routes

Source: The Last Mile Concept for the Bydgoszcz Logistics Hub, 2020.

6. Conclusions

Summing up the above considerations, it must be stated that the last mile at the Bydgoszcz Logistic Hub, which encompasses the Bydgoszcz-Solec Kujawski Multimodal Platform and the Bydgoszcz Emilianowo Intermodal Terminal, substantiates the realisation of the transhipment, storage and forwarding services in the area of Bydgoszcz and Toruń urban centres. The main advantage of the

location is its convenience for optimal transhipment of goods between the seaports of Gdańsk and Gdynia and main urban areas of Central Poland, i.e. to Warsaw, Łódź and Poznań. The connection with the Baltic-Adriatic Corridor and the Silesia region is of equally great importance (which was confirmed by the analysis carried out for the location study).

The construction of the Bydgoszcz Logistic Hub will bring improvement to the already existing road links leading to the most important logistic centres, located, on the one hand, in the Tricity seaports, where, presently, transhipment amounts to 76 m tonnes (mostly transported to the hinterland by road), on the other hand, in large economic centres in Poznań, Łódź and Warsaw.

According to the trends on the transport market, it is projected that the main type of freight in the future will recruit from the break bulk cargo (containerised goods), whence long- distance transport of oversized cargo will grow in significance, making inland waterways shipment an attractive alternative to road mode. This is where the advantage of the Bydgoszcz Logistic Hub can be found.

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References

Aized, T., Srai, J.S. (2014), "Hierarchical modelling of last-mile logistics distribution system", *International Journal of Advanced Manufacturing Technology*, Vol. 70 No. 5-8, pp. 1053-1061. DOI: 10.1007/s00170-013-5349-3

Bergmann, F.M., Wagner, S.M., Winkenbach, M. (2020), "Integrating first-mile pickup and last-mile delivery on shared vehicle routes for efficient urban e-commerce distribution", *Transportation Research Part B: Methodological*, Vol. 131, pp. 26-62. DOI: 10.1016/j.trb.2019.09.013

Carboni, A., Chiara, B.D. (2018), "Range of technical-economic competitiveness of railroad combined transport", *European Transport Research Review*, Vol. 10 No. 45, pp. 1-17. DOI: 10.1186/s12544-018-0319-3

Czermański, E. (Ed.) (2021), *E-book on Combined Transport in the Baltic Sea Region*, University of Gdansk, Department of Maritime Transport and Seaborne Trade Press, Gdańsk, available at: https://www.researchgate.net/publication/352799983

de Langen, P.W., Chouly, A. (2009), "Strategies of terminal operating companies in changing environments", *International Journal of Logistics: Research and Applications*, Vol. 12 No. 6, pp. 423-434. DOI: 10.1080/13675560902775725

de Langen, P.W., Figueroa, D.M.L., van Donselaar, K.H., Bozuwa, J. (2017), "Intermodal connectivity in Europe, an empirical exploration", *Research in Transportation Business and Management*, Vol. 23, pp. 3-11. DOI: 10.1016/j.rtbm.2017.02.003

Digiesi, S., Fanti, M.P., Mummolo, G., Silvestri, B. (2017), "Externalities Reduction Strategies in Last Mile Logistics: a Review", *Proceedings - IEEE International Conference*

on Service Operations and Logistics, and Informatics (SOLI), pp. 248-253. DOI: 10.1109/SOLI.2017.8121002

Ehmke J. (2012), City Logistics in Integration of Information and Optimization for Routing in City Logistics, Springer, Boston, MA.

European Commission (EC) (2021), "Delivering the European Green Deal", available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en (accessed 17 July 2021).

Ewedairo K., Chhetri P., Jie F. (2018), "Estimating transportation network impedance to last-mile delivery. A Case Study of Maribyrnong City in Melbourne", *The International Journal of Logistics Management*, Vol. 29 No. 1, pp. 110-130. DOI: 10.1108/IJLM-10-2016-0247

Gevaers, R., van de Voordea, E., Vanelslandera, T. (2014), "Cost modelling and simulation of last-mile characteristics in an innovative B2C supply chain environment with implications on urban areas and cities", *Procedia - Social and Behavioral Sciences*, Vol. 125, pp. 398-411. DOI: 10.1016/j.sbspro.2014.01.1483

Heaver, T.D. (2006), "The Evolution and Challenges of Port Economics", *Research In Transportation Economics*, Vol. 16 No. 1, pp. 11-41.

Ji, S.F., Luo, R.J. Peng, X.S. (2019), "A probability guided evolutionary algorithm for multi-objective green express cabinet assignment in urban last-mile logistics", *International Journal of Production Research*, Vol. 57, pp. 3382-3404. DOI: 10.1080/00207543.2018.1533653

Nathanail, E., Gogas, M., Adamos, G. (2016), "Assessing The Contribution of Urban Freight Terminals in Last Mile Operations", *Transport and Telecommunication*, Vol. 17 No. 3, pp. 231-241. DOI: 10.1515/ttj-2016-0021

Rodrigue, J. (2013), *The Geography of Transport Systems*, Routledge, New York.

Sdoukopoulos, E., Boile, M. (2020), "Port-hinterland concept evolution: A critical review", *Journal of Transport Geography*, Vol. 86, pp. 1-11. DOI:10.1016/j.jtrangeo.2020.102775

Shi, X., Li, H. (2016), "Developing the port hinterland: Different perspectives and their application to Shenzhen Port, China", *Research In Transportation Business & Management*, Vol. 19, pp. 42-50. DOI: 10.1016/j.rtbm.2016.05.004

The Last Mile Concept for the Bydgoszcz Logistics Hub (2020), Warszawa (unpublished version).

The Organisation for Economic Co-operation and Development (OECD) (2015), *Transport Outlook 2015*, International Transport Forum, Paris.

United Nations Economic Commission for Europe (UNECE) (2001), *Terminology on Combined Transport*, New York and Geneva, United Nations.

Wan, Y., Yuen, A.C.L., Zhang, A. (2014), "Effects of hinterland accessibility on US container port efficiency", *International Journal of Shipping and Transport Logistics*, Vol. 6 No. 4, pp. 422-440. DOI: 10.1504/IJSTL.2014.062908

Wojewódzka-Król K., Rolbiecki R. (2017), *Społeczno-ekonomiczne skutki zagospodarowania dolnej Wisły*, Acta Energetica, Gdańsk.