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The Cost of Hosting a Ferry Port: Assessing Baltic Ferry Ports' Negative Impact on Urban Areas and their Strategies to Mitigate it

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Abstract:

Purpose: *The purpose of the article is to assess the negative impact of the leading Baltic ferry ports on the urban areas where ferry services are provided, as well as the strategies adopted to mitigate this impact.*
Design/Methodology/Approach: *Several research methods were applied: literature review, data exploration method, desk research and comparative analysis. As this is a pilot study, the comparison is limited to: (a) the ferry ports with the largest turnover of wheeled cargo units; (b) selected criteria i.e., location, access infrastructure, investments in modern eco-friendly solutions.*
Findings: *(1) almost all leading ferry ports within the BSR have developed solutions aimed at reducing the negative impact of their cargo operations on the port city and environment; (2) some ferry ports have actively responded to the IMO's call to cooperate with shipowners subsumed in Resolution MEPC.323(74).*
Practical Implications: *This study allows to highlight the best practices to minimize the negative impact of ferry ports on urban areas, as well as indicate examples of effective cooperation with ferry operators in the BSR, which can be a model for other ferry ports.*
Originality/Value: *So far, no research has been conducted on the activities undertaken by the ferry terminals to eliminate the externalities of their activities, which causes a research gap in this area.*

Keywords: *Baltic Sea Region, ferry shipping, GHG emissions, ferry ports.*

JEL classification: *M21, L99, L83, C38.*

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1. Introduction

The Baltic Sea Region (BSR) is the specific area of European Union, belonging to the group of the most prosperous regions all-over the world (Grzelakowski, 2010) The high rate of trade development makes the Baltic Sea market a one of the fastest growing transport markets with ferry shipping being the basic form of transporting cargo units[3] in the intra-Baltic trade. Ferries and pure Ro-Ros carry up to 80% of the total internal cargo turnover in the region (Serry, 2014).

The number of wheeled units have been steadily increasing since the beginning of this decade. In 2019 around 50 million passengers, 9 million cars and 3 million cargo units were carried on the international ferry links within the Baltic Sea Region (ShippaxMarket19, 2019) The dynamic growth in the transport of Ro-Ro units in the BSR was also accompanied by the development of ferry ports, which had an impact on the urban areas.

Ports and cities affect each other in manifold ways (Urbanyi-Popiołek and Klopott, 2016). In addition to the economic significance of port activities to the regions, which is widely discussed in the literature (Park and See, 2016; Deng *et al.*, 2013), ports have also a negative impact on the urban areas generating the external negative effects (e.g., traffic congestion, noise, air emissions), lowering the living standard in urban areas (Iwan and Kijewska, 2016; Zhao *et al.*, 2017), as well as contributing to health problems of inhabitants. Some of these environmental challenges are taken very seriously by the International Maritime Organization (IMO), and recent years have been the years of the battle in various areas to minimize the negative impact of shipping on the environment (e.g., reduction of the emission of sulphur oxides, nitrogen oxides, and GHG gases, improvement of ship energy efficiency etc.).

Although the burden of adapting to the increasingly demanding regulations fell mainly on the shipowners, however seaports, including ferry ports, were not excluded from this battle to improve the environments. First, the landmark IMO Initial Strategy on GHG emissions from shipping (IMO, 2017) called for the encouragement of port developments and activities globally to facilitate reduction of emissions of greenhouse gases. Second, this call was explicitly repeated in 2019 by the Resolution MEPC.323(74) on the Invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions from ships.

In the light of dynamic development of transportation of wheeled units within the BSR and having in mind the impact of shipping on the environment, the purpose of the paper is to assess the negative impact of the leading Baltic ferry ports on the urban

[3]*Cargo units – in this paper the following terms are used interchangeably: cargo units, wheeled units, and ro-ro units, which include trucks (lorries), trailers, semitrailers, and rail cars.*

areas where ferry services are provided, as well as the strategies adopted to mitigate this impact. The achievement of the research goal may take place only after obtaining answers to the following research questions:

RQ1: What activities, if any, are undertaken by ferry ports/terminals to reduce the negative impact of their cargo operations on the port city?
RQ2: Are ferry ports already taking actions to facilitate the reduction of greenhouse gas emissions from ships, i.e., to what extent do they respond to IMO's call to cooperate with shipowners subsumed in Resolution MEPC.323(74)?

It is worth noting, that studies discussing ferry shipping primarily focus on the research into the ferry markets, supply and demand developments (Urbanyi-Popiołek, 2018; Serry, 2014), the passenger segment and customer requirements (Mańkowska and Tłoczyński, 2018; Mathisen and Solvoll, 2010), cargo traffic and the role of ferries in short sea shipping, intermodal chains and the sustainable development of transport (Kotowska, 2015; Musso *et al*., 2010, Studzieniecki and Urbanyi-Popiołek, 2018). These studies usually ignore the activity of ferry terminals in the cargo segment unless it concerns the analysis of the turnover of selected ferry ports. Moreover, no research has been conducted on the activities undertaken by the ferry terminals to eliminate the externalities of their activities, which causes a research gap in this area.

2. Study Design and Results

To achieve the purpose of the article and answer the research questions, a desk research study was conducted to gain a broad understanding of the researched field. First, information and data from ferry ports websites have been systematically gathered and scrutinized in recent years. Furthermore, newsletters, and data issued by ferry ports and ferry operators, referring to cargo turnovers, ports' infrastructure, and development plans, have been carefully analysed. ShipPax Information, known as a reliable publisher and provider of consultancy services for the ferry industry, was an invaluable source of primary data and information on the volumes of cargo transhipped in the Baltic ferry ports, as well as on the activities of ferry ports.

The study is of a pilot nature; therefore, the comparison is limited to: (a) the ferry ports with the largest turnover of wheeled cargo units; (b) the three selected criteria, which are described below.

The ports with the highest ferry turnover (cargo segment) in the Baltic Sea Region were selected for the analysis, as the greater the total turnovers of wheeled units and the number of calls per day, the greater the lorry traffic passing through the ferry ports, and thus the greater negative effects on the urban areas, where these terminals are located. These ports include: Trelleborg, Stockholm and Ystad (Sweden), Tallinn (Estonia), Rostock and Travemünde (Germany), Helsinki (Finland), Świnoujście (Poland), and their annual transhipments range from less than 200 thousand to as much as 766 000 units. For example, in the largest Trelleborg the number of daily calls fluctuates around 14-16 sailings, the average number of trucks transported by the largest Ro-Pax ferries amounts to 200-240 units discharged and loaded per single trip, what gives about 1600 units handled by port daily. A detailed data regarding ferry cargo turnovers, number of calls and other are presented in Table 1 at the end of this section 2.1.

The overall assessment of ferry ports in terms of their negative impact on urban areas is complex due to the wide range of criteria influencing the port-city interface. In this study, three criteria were selected for the analysis. Two of them relate to the location of ferry terminals and their access infrastructure, as they are important determinants affecting the urban areas. Another one concerns investments in modern eco-friendly solutions undertaken by ferry ports to minimize their negative impact on air quality.

2.1 Location of Terminals and their Accessibility

Ferry terminals within the BSR are situated in various distance from city centres, outside (e.g., Travemünde), nearby with convenient access (e.g., Trelleborg) or in the very city centres (e.g., Helsinki, Stockholm).

It is widely acknowledged that in-port operations like handling cargo and ships manoeuvrings while entering or leaving the port generate emissions and noise. Moreover, increased truck traffic between the port and the hinterland intertwines with passenger traffic on certain routes in the city centres, leading to congestion, delays, accidents, and being a source of harmful pollutants. Generally, the closer the terminal is to urban areas, the greater negative externalities generated. Therefore, the location of ferry ports and the access infrastructure to ferry terminals, which is to some extent related to the location of the port, is so crucial.

The access to the port area bypassing the cities (by road or by rail) is one of the critical factors in reducing congestion and other externalities. Especially, implementation of rail connections between the ferry ports and the hinterland is very important, because the wheeled units can be transported then by intermodal trains, each with an average capacity of 30-35 trailers, thus reducing their number on urban and access roads.

Efficient rail/intermodal connections are highly developed in three ferry ports, Trelleborg, Rostock and Travemünde. The railway lines provide the connection from the ferry port areas to the rail network in the countries. The railway lines from these terminals are also linked with the main AGCT network in Germany and other western European countries. According to the information collected from the ports of Trelleborg and Rostock, the intermodal units account for as much as 22% and 18% of the total cargo turnover, respectively. Apart of favourable intermodal connections, these ports are conveniently accessible by road.

In the port of Travemünde, which is a district of Lübeck, four terminals handle wheeled cargo, and the biggest, Skandinavienkai, is dedicated to ferry traffic. The terminal is directly connected via the own spur road with A1 motorway linking Lübeck and Hamburg with the main economic centres of Europe.

Unlike Travemünde, Trelleborg, is located on the outskirts of the town, quite close to the urban areas. Apart of rail connections, it is easily accessible from the hinterland by road. The road traffic is directly linked with public roads (motorway E22 to Malmoe and R9 to east) bypassing the urban area avoiding congestion in the city area.

The ferry port in Rostock is in the Warnemunde area, a northern district of the city. The motorway A19 and the road B105 link the port directly bypassing the urban areas. Ferry terminal is easily accessible from the hinterland by rail and by road.

The Swedish ferry port in Ystad is also linked with the hinterland both by road and by rail. Ystad is a part of the railway line Malmoe-Simrishamn and is connected by rail with Copenhagen via the Oresund Bridge. It is also conveniently separated from the city centre by the international road E65, and all heavy traffic from the port is directed through the industry zones straight to the road E65 that begins just at the port and connects Ystad with Malmoe and the main road network.

Currently, the worst access to the ferry terminal, both by road and rail, is at the ferry port in Świnoujście. Although the expressway S3 (part of international road E65), begins at the terminal and passing the industry zones runs south connecting to the main network (expressway S6 and motorway A2), the smooth road access is still hampered by a delay in the construction of the most significant section of 32 kilometres from Świnoujście to neighbouring Szczecin. Regarding the rail access, the rail truck leading to the ferry port is being modernized, and the new intermodal terminal is still under construction.

Among the selected ferry ports, there are three, which are sited in the very city centres: Helsinki, Tallinn, and Stockholm. Regrettably, the access to these ports is mainly provided by road connections. However, many restrictions of heavy traffic movements have been adopted to steer it straight onto major routes.

In Tallinn, the international road E67 starts near the ferry port, thanks to which the trucks are directed straight to the motorway, avoiding city roads. However, traffic still passes through most urban areas.

Ferry traffic in Stockholm is concentrated in two areas, Vartahamnen and Stadsgarden. Vartahamnen is situated close to the motorway E20, which connects the terminal directly to the road network, that passes the city from the north. Traffic from the Stadsgarden terminal is via the main ring roads connecting to the E20 motorway bypassing the city centre from the west.

In the port of Helsinki, trucks are allowed to move only on marked routes connecting the terminals with the network of country's - the northern and western ring roads, but they still pass through densely populated areas of the city. Here, ferry traffic is served at three areas: South Harbour, West Harbour, and Vuosaari Harbour. Interestingly, Hansa Terminal in the Vuosaari Harbour is the only port area with a railway connection.

It is worth noting, that the location of these ports in the centres of the urban areas is historically determined or results from strong tourist functions of ferry shipping on the Baltic eastern markets. The most important thing is whether they undertake measures to minimize their negative impact, despite being situated in the city centre. For example, in Trelleborg the relocation of the ferry berths more towards the sea is now under development. It means significant environmental benefits, including the air quality, amongst other, as the ship traffic moves further away from the central of Trelleborg.

In cities where ferry terminals are centrally located, ports are investing in new terminals located far from cities to handle ferry cargo traffic. Examples include Mugga Harbour and Paldiski South Harbour, managed by the port authority of the port of Tallinn, or the ro-ro terminal Stockholm Norvik.

Table 1. *Summary of basic data on selected Baltic ferry ports.*

Port	No. of ferry calls (2018)	No. of trucks (2018)	Location	No. of terminals/ berth	No. of ferry services/ operators	Land connectio ns
Trelleborg	5 137	594 740	close	1/8	7/3	road, rail
Travemünde	4 349	766 158	outside	1/9	4/4	road, rail
Helsinki	6 426	431 107	in city /close (Vuosaari)	4/9	6/4	road, rail (only Vuosaari)
Rostock	6 034	463 828	outside	1/5	3/3	road, rail
Tallinn	5 778	406 632	in city	2/9	5/3	road
Stockholm	3 542	186 387	in city	2/7	6/2	road
Świnoujście	3 827	488 128	outside	1/5	4/3	road, rail
Ystad	3 793	267 523	close	1/5	3/3	road, rail

Source: *Own elaboration based on the port information and Shippax Market19.*

2.2 Investments in Modern Eco-Friendly Solutions

As it was mentioned earlier, the activity of ferry terminals generates the externalities in urban areas, including air emissions, and noise. Emissions (nitrogen oxides, sulphur oxides and GHG) come from a variety of sources, as ferries calling at a port, while manoeuvring and lying at berth, from loading and unloading operations, as well as from road and rail transport. are the key air emissions from the port operations and ferry traffic. Noise in the terminals is caused by the ferries` main engines, as well as the vessels' ventilation systems and the use of auxiliary engines when the ship is moored, as well as by loading and unloading operations (handling equipment and vehicles also cause noise as they move around the terminals).

In response to the IMO's call in Resolution MEPC.323(74), many ports around the world have already adopted environmental solutions regarding the reduction of GHG emissions. These include but are not limited to the provision of:

- Onshore Power Supply (preferably from renewable sources),
- Automated Mooring System,
- emission-reducing technologies as e.g., use of electric handling facilities,
- safe and efficient bunkering infrastructure for alternative fuels.

To reduce noise and emissions the terminals invest in the Onshore Power Supply (OPS). The shore power system is a solution based on connecting the vessel to the shore-side electricity during berthing in the port. This means that vessels do not need to use their auxiliary engines to generate electricity whilst moored and thus reduce emissions and noise created by the ships' engines. According to the port of Tallinn Authorities, a ship that uses the green shore power for at least 7 hours per day while docked in the port generates 230 tonnes less CO_2 per month. Connecting to the OPS reduces the emissions generated by the ship`s engine: CO emissions by 99%, and CO_2 and NO_X emissions by over 50% (Shippax Information, 2019).

Among the analysed ferry ports, OPS systems are offered by terminals in Travemünde, Trelleborg (all berths), Ystad, Stockholm (both terminals) and Helsinki (South Harbour Terminals) and, recently, also by the port of Tallinn in the Old City Harbour. The other two ports did not install the OPS on their ferry berths yet. However, the terminal in Świnoujście considers the shore system as a part of the modernization and reconstruction of the terminal infrastructure.

The new investments in Tallinn as well as enlargement of the OPS in two other capitals resulted from the earlier (in 2016) agreement between the ports of Helsinki, Stockholm, Turku, and Tallinn i.e., a memorandum of understanding (MOU) to establish a common approach in providing a new onshore power supply for vessels. All these investments were carried out in cooperation with ferry carriers in the region, who adapted their ferries to the OPS. For example, Viking Line adjusted their ferries serving routes from Stockholm to Helsinki and Turku. Shore power is also used by four Tallink - Silja ferries operating the Estonian-Swedish as well as Estonian-Finnish routes. There are also three ferries on Trelleborg and Ystad route operated by Unity Line, Stena Line and Polferries, as well as the Finnlines ships deployed on the Helsinki- Travemünde route, that are equipped with OPS.

Another innovative solution adapted in ferry ports is the Automated Mooring System (AMS). It eliminates the need for conventional mooring lines by replacing them with automated vacuum pads that moor and release vessels. In the ferry terminals equipped with AMS, CO_2 emissions during berthing can be reduced by as much as 97%. The difference compared to the conventional system is the time required for mooring. Mooring the ferry in the traditional system takes about 15 minutes, while in the case of AMS it takes only 15 seconds (Díaz-Ruiz-Navamue *et al.*, 2018). Ferries are then equipped with thrusters, so the mooring time is shorter, and the emission is lower compared with other types of ships.

The first AMS in the ferry ports was introduced in the Helsinki West Harbour in 2016, where the second system was installed at the end of 2020. The AMS is under construction on two berths in the Tallinn Old Town Harbour. Consequently, all ferries operating the Tallinn-Helsinki route will move automatically. Similarly, the Helsinki Port Authority plans to equip all piers with a system in the Western Terminals (1 and 2) and in the Old Town Port in the future.

Ferry ports are also investing in technologies that reduce emissions from port handling facilities and vehicular traffic. The equipment of the ferry terminals primarily consists of tractors and forklift trucks, as the ro-ro technology is typical for ferry shipping. Occasionally RMG gantries are used in intermodal terminals. In Trelleborg and Travemünde fossil-fuelled terminal vehicles and equipment was replaced with the electric and hybrid ones, thus reducing noise and air pollution. This is of particular importance, as both ports handle many unaccompanied semitrailers which results in more intensive terminal transport and the use of more terminal tractors. Similar investments in eco-friendly equipment are made in Helsinki, Stockholm, and Tallinn. The remaining ports use primarily the handling equipment powered by traditional fuels, and the most outdated and requiring replacement is in Świnoujście and Ystad.

To meet strict environmental legal requirements for reducing emissions imposed on shipowners by the IMO, some of them decided to turn to LNG technology, which allows for a significant reduction in CO_2, SO_X, and NO_X emissions. It requires one of three types of dedicated LNG bunkering infrastructure, tank-to-ship, ship-to-ship or terminal-to-ship refuelling, for which close cooperation between ports and ferry operators is necessary.

The port of Stockholm was the first port within the Baltic Sea Region where LNG as a fuel started to be available for ships. The port started to perform the LNG bunkering operation in January 2013 when the first LNG-powered ferry "Viking Grace", sailing from Stockholm to the Aland Archipelago and Turku, was put into service. A year later, the port of Helsinki also began offering tank-to-ship LNG refuelling. The newest LNG-powered ferry, which use this option is the Tallink's "Megastar", running on Helsinki–Tallinn route. The port of Rostock has gone a step further as it has recently offered more advanced ship-to-ship LNG bunkering operation.

Among other analysed ports that consider or plan to develop LNG bunkering infrastructure is Trelleborg, which take part in "LNG in the Baltic Sea Ports II" Project co-financed by the EU. Similarly, the port of Świnoujście is going to deploy LNG bunkering vessel by 2022.

As LNG is becoming an increasingly attractive option to shipowners, one can expect further development of LNG bunkering solution in ferry ports. Surely, other ports would respond to ferry operators needs if they decided to put LNG-fueled ferry in operation on their routes.

2.3 A Brief Summary of the Results

The above analysis demonstrates that almost all leading ferry ports within the BSR have developed solutions aimed at reducing the negative impact of their cargo operations on the port city and environment (the answer to RQ1). Table 2 summarizes the results of the study, that allows to assess the performance of selected ports in terms of their location, accessibility, and investments in modern eco-friendly solutions. The plans of these ports for improvements, such as e.g., relocation of the ferry quay and investments in pro-ecological solutions were also additionally appreciated.

Table 2. *Summary of performance of the analysed ferry ports regarding selected criteria.*

Port /criterion	Location	Road access	Rail access	Handling equipment	OPS	AMS	LNG Bunkering
Trelleborg	+ (+)	+	++	++	++	0	(+)
Travemünde	++	++	+	++	+	0	0
Helsinki	- (+)	-	0	+	++	++	++
Rostock	++	++	++	+	-	0	++
Tallinn	- (+)	-	0	+	+	++	++
Stockholm	- (+)	+	0	+	++	0	++
Świnoujście	+	- (+)	-	-	- (+)	0	(+)
Ystad	+	+	++	-	+	0	0

Note: *++ very good; + good; - poor; 0 – none, but because of the lack of investment opportunities or because of a highly innovative solution; (+) improvement plans*
Source: *Own elaboration.*

The above comparison clearly shows that the ferry port in Rostock (9 "+") developed the best solutions to reduce its negative impact on the city and the urban area. Trelleborg (8 "+" and 2 "(+)") and Travemünde (8 "+") presents almost equally high performance regarding the port-city interface as Rostock and are distinguished by the best eco-friendly handling equipment.

Praise is also due to the in-city ferry ports (Stockholm, Helsinki, Tallinn) that, despite their location, strive to be better and better in their efforts the be city-friendly. Against this background, the Polish ferry port of Świnoujście (2 "+" and 2 "(+)") fared the worst in this comparison, however, according to its development plans, there is a hope, that its impact on the urban areas will improve in the future.

Almost all selected ferry ports are already taking actions to facilitate the reduction of greenhouse gas emissions from ships. However, it cannot be overlooked, that without the cooperation with ferry operators, solutions such as OPS, AMS, or LNG-bunkering, would not take place. This means, that some ports have actively responded to the IMO's call to cooperate with shipowners subsumed in Resolution MEPC.323(74) (the answer to RQ2). The ferry port of Helsinki can be a model for other Baltic ports.

3. Conclusions

The dynamic growth in the transport of ro-ro units in the BSR is also accompanied by the development of ferry ports. Despite their economic significance to the region, they have, as it was presented, also a negative impact on the urban areas and the environment. Fortunately, most of selected ferry ports, make every effort to reduce this negative impact, improve their environmental performance, using the most advanced technologies.

This pilot study allows to highlight the best practices to minimize the negative impact of ferry ports on urban areas, as well as indicate examples of effective cooperation with ferry operators in the BSR, which can be a model for other ferry ports.

The article represents a contribution to further detailed research on the impact of activities of the ferry port on urban area and the effects of implemented solutions. Future lines of research should embrace more ferry ports acting within the BSR and should involve the analysis of more criteria impacting port-city interface.

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