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THE ECONOMIC ROLE OF BALTIC SEA REGION SEAPORTS IN CHANGING GEOPOLITICAL CONDITIONS

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ABSTRACT

Motives: Seaports are key nodes in the Trans-European Transport Network (TEN-T), handling a significant part of the European Union's trade and freight transport. Baltic Sea ports, including those in Poland, have gained strategic importance due to their high growth rates and intense maritime traffic.
Aim: This article examines the economic role of Baltic Sea ports under changing geopolitical conditions. It proposes two hypotheses: one on the relationship between economic growth and port cargo turnover, and the other on the strengthening positions of Baltic ports as key logistics hubs. The study analyzes statistical data on port cargo turnover, functional models, and classifications using Pearson's correlation and structural analysis.
Results: The main conclusions highlight the strengthening positions of Baltic Sea ports despite current challenges, emphasizing the need for further infrastructure development and service quality improvement. This article contributes to the field by providing a comprehensive analysis of the role of Baltic Sea ports, taking into account current geopolitical and economic factors, and by proposing an approach for assessing their current status and development prospects. The results are potentially useful for strategic planning in maritime transport.

Keywords: Baltic Sea Region, seaports, ports model, ports classification, hinterlands

INTRODUCTION

Seaports in the Baltic Sea Region (BSR) occupy a central role in the global logistics system, performing functions such as delivery, processing, and storage of various types of cargo. They serve as key nodes in the distribution network for goods and services, meeting the region's needs for essential resources like food, raw materials, equipment, hydrocarbons, etc. According to recent data, 87 ports in the BSR are part of the Trans-European Transport Network (TEN-T), specifically comprised of 22 core ports with the remaining 65 being comprehensive ports (Baltic Ports Organization, 2022).

The article proposes a comprehensive assessment of the current economic and strategic role of Baltic Sea ports amidst changing geopolitical and macroeconomic conditions. In particular, an analysis of the dynamics of Baltic Sea port's key performance indicators is conducted in order to identify leading trends and patterns. In addition, the role of Baltic Sea ports in ensuring regional countries' transport and logistics needs is considered.

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Two research hypotheses are presented:

H1: There is a statistically significant positive correlation between the Gross Domestic Product (GDP) and cargo turnover of Baltic Sea ports. This hypothesis posits that during the analyzed period, there was a positive relationship between economic growth, as measured by GDP, and port cargo turnover in the region. It suggests that along with GDP growth, there was an increase in the port cargo turnover. This hypothesis was tested using Pearson's correlation method.

H2: Despite problems associated with the pandemic and geopolitical changes, Baltic Sea ports, including Polish ports, are confidently strengthening their position as key logistics hubs in Europe. To test the hypothesis, this article analyzes key performance indicators of ports, their functioning models and classifications. This will assess the current situation in the Baltic ports and determine the direction for their further development.

The development and operation of seaports require a thorough methodological approach due to their complex structure and multifaceted role in the economy. A port is not just an infrastructure complex; it is also an important transport hub that facilitates effective interaction between maritime and land transport.

The importance of BSR seaports is enhanced by their strategic location, which provides a link between Western and Eastern Europe. This strategic location makes them an integral part of the European economy, promoting trade and investment growth. In addition, BSR ports are actively integrating with other modes of transport, such as rail and road, to create multimodal logistics chains. This integration enhances their efficiency and resilience to external challenges. In light of global environmental trends and the pursuit of sustainable development, ports are also actively introducing "green" technologies aimed at reducing emissions and minimizing their negative impact on the environment. For example, some ports are developing and implementing applications to improve coordination mechanisms and information exchange between ports and vessels. The ports of Rauma in Finland and Gavle in Sweden have been selected as pilot ports (De A. Gonzalez et al., 2021).

With globalization and the accelerated development of international trade, the seaports of the BSR have evolved into not just logistics hubs but also significant economic centers. These centers contribute to the growth of local economies. Their role in regional development is amplified by job creation, investment attraction, and the stimulation of scientific and technological progress.

In addition, BSR ports actively cooperate at the international level, participating in various projects and initiatives aimed at improving infrastructure, safety, and environmental sustainability. This cooperation, in turn, facilitates the exchange of experience and the best practices between ports from different countries. In a constantly changing world and faced with new global challenges such as climate change and digital transformation, BSR ports are actively adapting by introducing new technologies and methods. This adaptability allows them to remain competitive in the global market as well as meet modern requirements and standards. The seaports of the BSR not only ensure the efficient movement of cargo and passengers but also play a key role in the socio-economic development of the region, serving as a bridge between different cultures, economies, and technologies.

LITERATURE REVIEW

As cities grew in size and port capacities expanded, an initial spatial and functional segregation emerged between ports and cities. The development of "outports" in Northwestern Europe (Pounds, 1947) and the growth of ports in the UK illustrates the trend of ports moving away from central urban areas. The "Anyport" port development model, proposed by Bird (1963), examines the emergence of a port, its expansion, the specialization of berths and docking lines, handling equipment, as well as spatial development characterized by deep-water, multipurpose berths in the city's open spaces.

Hayuth (1982), who presented the concept of port-city interaction, noted that with the advent of con-

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tainerization and new cargo handling technologies, port land use has changed dramatically, and many previously profitable port sites have ceased to be seen as competitive. Moreover, such an expansion was seen as a movement in port development and hinterland strengthening[1].

The hinterland is defined as an inland area where a transport terminal, such as a port, offers its services and interacts with its customers. The hinterland constitutes the terminal's regional market share in comparison to other terminals serving the same region. Each transport terminal has its hinterland, which represents the complete set of consumers involved in production and trade activities with which the terminal interacts. As a result of these transactions, cargo is moved, and in some terminals, this cargo is transshipped. This movement is associated with areas known as the primary hinterland and the competitive range. The primary hinterland is the area where the terminal holds a dominant share of cargo flows and serves as the terminal's traditional core market area, being the most territorially accessible (Rodrigue & Notteboom, 2006).

Thus, the hinterland refers to the inland catchment area of a seaport, transport hubs and networks that are focused on and specialized in serving a port's cargo.

Morgan (1958) proposed a hierarchy of hinterlands that includes primitive, commodity, and trunk line port hinterlands. Primitive hinterlands lack alternative maritime "outlets" (e.g., islands), and transportation to other coastal ports is underdeveloped. Commodity hinterlands are associated with bulk cargo and utilize specialized ship types such as tankers. The ports in these hinterlands are strategically located to minimize the inland transportation of bulk cargo over the shortest possible distance. Trunk line port hinterlands, which are the most complex in structure and largest in size, are multifaceted; they handle a variety of cargo types (both bulk and general) and require the provision of diverse services.

In the early 1990s, a model was endorsed at the United Nations Conference on Trade and Development (UNCTAD) to evaluate changes in types of cargo flow as well as long-term port development strategies. Additionally, the model provides for the expansion of port territory as a "service center" (Beresford et al., 2004). Subsequent research has shown that the existing model has exhausted its potential, leading UNCTAD to propose new approaches for port development in 2014. Greater attention is now being paid to the port management system. To this end, a program has been created to support port administrations in ensuring efficient and competitive port management, which in turn strengthens trade support and economic development. Within the framework of this program, port networks are established that bring together state, private, and international organizations. In these networks, port operators from both public and private organizations share information, knowledge, and experience.

New trends in port development have been identified, which envision the creation and development of special port economic zones and free customs zones. Additionally, there are plans to increase port throughput capacity via enhanced logistics and upgraded port equipment, especially for serving container ships. Significant attention is being paid to the automation of management processes and the active use of information systems, with plans for their subsequent integration into global supply chain management systems.

The port regionalization model by Notteboom and Rodrigue (2005) has gained significance in scientific research on port development. This model examines port development in the context of increasing urbanization, which helps explain the emergence of various logistics centers and the challenges of integrating ports into their hinterlands. The port regionalization model considers "offshore ports", which operate on islands, and continental ports with limited hinterlands as the foundation for a single container freight consolidation system through the creation of hubs and back-office logistics platforms.

[1] Every seaport has a strong attraction to the surrounding territories, known as hinterlands. However, the term "hinterland" can be applied not only to the area beyond a seaport but also to areas beyond other natural or technical objects. Hinterlands are most commonly associated with ports.

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Additionally, the model highlights the active role of inland freight terminals in shaping the regional freight turnover network and expanding the port hinterland.

It should be noted that the seaports of the Baltic Sea Region occupy a central place in global transport infrastructure, performing the function of critical transport hubs that contribute to the economic and sociocultural development of the region. In particular, the ports of Poland, as well as the port of Klaipeda (Lithuania), located on the Baltic Sea coast, act as important transport hubs of the West-East corridor, integrating land and maritime communication routes (Gaidelys & Benetyte, 2021). Their strategic importance as an intersection between East and West has increased since the Baltic Sea became an internal sea of the European Union (2004) (Serry, 2022).

Nevertheless, a number of small- and medium-sized Baltic ports face limited financial support from European funding programs due to their remote locations from the core TEN-T network (Meyer et al., 2021). Despite these challenges, they continue to play a key role in the regional economy by providing access to individual regions and stimulating both socio-economic and environmental development. This role is becoming increasingly relevant in light of the EU Commission's policies on food security and Smart Specialization, which are aimed at supporting regional economic growth and innovation (Meyer, 2021).

In addition, the creative industries are one of the most dynamic sectors in the Baltic Sea Region's economy, accounting for 3% of global GDP and providing 29.5 million jobs. These industries play a crucial role in improving the quality of life by promoting social integration and cultural exchange (Klein et al., 2021).

The seaports of the Baltic Sea Region are entering a new era of digital transformation and sustainable development. Digital innovations can become a catalyst for sustainable economic growth in the Baltic Sea coastal areas. This highlights the commercialization of territorial resources and the effective use of the unique opportunities of coastal zones. Despite facing numerous challenges related to financing and environmental issues, ports are discovering new pathways toward sustainable development through research and innovative approaches, such as Blue Growth (Rijkure, 2017). Port benchmarking demonstrates how ports can optimize their infrastructure and cargo flows to achieve maximum efficiency (Liebuvienė & Čižiūnienė, 2022).

A thorough analysis of legal acts and strategic documents, both at the European Union and Polish levels, indicates the growing importance of seaports in the Baltic Sea Region. This importance manifests itself not only in the strictly economic dimension, as a driving force for economic development, but also in the context of complex challenges related to sustainable development and environmental protection. The "Transport Development Strategy until 2020 (with a perspective until 2030)" unequivocally identifies seaports as key nodes in the transport network, emphasizing the urgent need for their modernization and increased competitiveness (Ministerstwo Transportu, Budownictwa i Gospodarki Morskiej [Ministry of Transport, Construction and Maritime Economy], 2013). In turn, the "Development Program for Polish Seaports until 2030" presents a holistic and far-reaching approach to strengthening the position of Polish ports among Baltic ports and increasing their role as strategic links in global logistics chains (Ministerstwo Gospodarki Morskiej i Żeglugi Śródlądowej [Ministry of Maritime Economy and Inland Navigation], 2019).

At the level of national legislation, the Act on Seaports and Harbors creates a solid legal framework for the functioning and management of ports in Poland, regulating in detail issues such as ownership structure and financing principles (Ustawa z dnia 20 grudnia 1996 r. o portach i przystaniach morskich [Act of 20 December 1996 on Maritime Ports and Harbors], 1997). These regulations are of fundamental importance for ensuring a stable and predictable legal environment, necessary for long-term investments and sustainable port development.

In the international dimension, the Baltic Sea Action Plan adopted by the Helsinki Commission gives priority to the role of ports in reducing negative

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impacts on sensitive marine ecosystems, including through the development of advanced infrastructure for receiving waste from ships (HELCOM Baltic Marine Environment Protection Commission, 2021). This strategic document fits into the broader trend of sustainable development and emphasizes the need for a holistic approach to the maritime economy, in which ports play a key role in reconciling the imperatives of economic growth with environmental protection. The updated action plan sets ambitious goals and defines concrete actions to achieve good ecological status of the Baltic Sea, which has significant implications for the functioning and development of ports in the region.

The Baltic Sea Action Plan strengthens and updates the premises regarding the growing role of seaports in the Baltic Sea Region, with particular emphasis on environmental aspects and sustainable development. This strategic document highlights the need for ports to adapt to changing conditions and challenges, such as climate change, biodiversity loss, and marine pollution. At the same time, it points to the potential of ports as key players in the transition towards a green and sustainable maritime economy.

The EU Strategy for the Baltic Sea Region, a key instrument of cohesion policy, lists among its priorities the improvement of transport connections and the elimination of infrastructure bottlenecks. The implementation of these postulates is necessary for the efficient functioning of ports and the full utilization of their potential as catalysts for economic development (European Commission, 2012). In a complementary manner, the "Sustainable Blue Growth Agenda for the Baltic Sea Region" recognizes the enormous potential for sustainable development of the maritime economy, including ports. This agenda emphasizes the need to find a delicate balance between the imperative of economic growth and the urgent need to protect unique marine ecosystems (European Commission, 2014).

At the EU legislative level, the directive establishing a framework for maritime spatial planning plays a fundamental role in harmonizing port development planning with competing forms of maritime space use, such as wind energy, fisheries, and nature protection (Directive 2014/89/EU). On the other hand, the regulation on Union guidelines for the development of the trans-European transport network (TEN-T) sets high standards for port infrastructure and highlights the strategic importance of ports as multimodal transport hubs, integrating various modes of transport (Regulation (EU) No 1315/2013).

The discussed documents unequivocally point to the urgent need for strategic investments in modern port infrastructure, increasing the competitiveness of ports in the international arena, and strengthening multifaceted cooperation in the Baltic Sea Region. At the same time, they strongly emphasize the necessity of fully integrating environmental aspects into port development and harmonizing maritime spatial planning. The analysis shows a high correlation and consistency between these documents and the issues presented in the article, providing a solid theoretical foundation for the thesis of the growing role of seaports in the Baltic Sea Region in dynamically changing geopolitical and economic conditions.

DETERMINANTS OF THE FUNCTIONING AND CLASSIFICATION OF BALTIC SEA PORTS

The Baltic Sea connects the territories of nine countries: Germany, Poland, Sweden, Russia, Estonia, Latvia, Lithuania, Denmark, and Finland. These countries, diverse in both development potential and culture, are united in terms of integration by their seaports. Moreover, seaports serve as nodal centers on the Baltic Sea, performing a variety of complex functions, ranging from serving as capital cities to acting as the world's largest transport centers. Sweden and Finland have the longest coastlines along the Baltic Sea. The seaports of the Eastern and Western Baltic Sea differ significantly from each other. For instance, the ports of Germany, Denmark, Southern Sweden, Poland, and the Kaliningrad region are closely linked to the handling and processing of cargo in Western and Central Europe. Meanwhile, the Eastern ports

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are more focused on managing cargo flows within the Baltics, Russia, and Scandinavia (Bilczak et al., 2020).

The structure of ports typically consists of specialized terminals for specific types of cargo, strategically distributed at berths. These ports also feature sites for cargo storage, warehouses, and cold storage facilities. Additionally, they house port administration and control services, as well as freight forwarding, insurance, and logistics companies that engage in complex cargo handling and transportation.

Each seaport serves its primary functions. Beyond handling, transport, and distribution, individual ports also fulfill spatial and transport-technological functions. These are often associated with port and industrial complexes. Industrial enterprises located near terminals benefit significantly from this proximity, as it reduces the transportation costs of finished products to other countries and eliminates the time and financial expenses associated with delivering finished products to the port.

Another feature of a Baltic Sea port is their ice regime, port basin depths, and the length of the approach channels. These conditions are especially important for the transportation of oil and petroleum products, as ice conditions play a crucial role. This is because, the Gulfs of Finland and Bothnia, as well as many other coastal areas of the Baltic Sea, are covered with ice throughout the winter period. This significantly hampers navigation and necessitates additional financial expenditures for the use of an icebreaker fleet. Therefore, from a safety perspective, many countries are compelled to increase and apply differentiated port tariffs for tankers with double hulls and other double-hulled vessels. The depth of the port basin is also a critical factor for port development, as it determines the size and draft of ships that can enter the port. In many Baltic ports, channel depths must be continually deepened, which is a costly endeavor (Bilczak et al., 2020).

Currently, the seaports of the Baltic Sea Region are evolving into centers of innovation and technological development. Many ports are actively introducing digital solutions to optimize operations and manage cargo flows (de la Peña Zarzuelo et al., 2020). Environmental considerations are also a focus in port upgrades. Due to growing attention to environmental safety, ports are adopting "green" technologies, such as the use of alternative energy and transitioning to more environmentally friendly fuels for vessels (Stankevičienė et al., 2020). Additionally, ports are active participants in international cooperation, implementing joint programs to develop infrastructure, improve maritime safety, and protect the marine environment (Gänzle, 2018; Grönholm & Jetoo, 2019). Owing to the growth in tourism, many ports have become significant tourist centers. The annual arrival of cruise liners contributes to an influx of tourists and the development of the local economy (Djakona & Kikste, 2023). Thus, Baltic ports continue to play a key role in the region's development, spanning the areas of logistics, innovation, ecology, and tourism (Gänzle, 2018; Gløersen et al., 2019; Raszkowski & Sobczak, 2019).

The determinants of the Baltic Sea ports model may be presented as follows (Fig. 1):

- External markets – sources and destinations for goods passing through Baltic Sea ports. These markets may include other countries or continents that engage with the Baltic Sea Region through seaborne trade.
- Baltic Sea ports – major hubs through which goods enter or exit the region. These ports facilitate the transshipment, storage, and onward distribution of goods.
- Inland transport – after goods pass through the ports, they are transported to their final destinations within the region by various means of inland transport, such as roads, railways, or inland waterways.
- Regional markets – final destinations for goods passing through the ports. These can include cities, industrial zones, or other key markets within the Baltic Sea Region.
- Digital infrastructure – modern ports are increasingly integrating digital technologies for process automation, efficiency improvements, and ensuring seamless interaction between various supply chain stakeholders.

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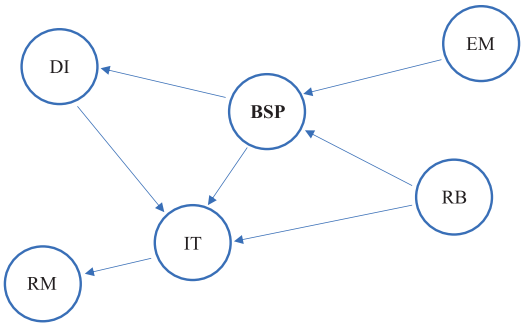
– Regulating Bodies – Authorities that establish rules and standards for port operations, ensuring safety, resilience, and compliance with international standards in light of changing geopolitical conditions.



Where: EM – External markets, BSP – Baltic Sea ports, IT – Inland transport, RM – Regional markets, DI – Digital infrastructure, RB – Regulating bodies.
Fig. 1. Baltic Sea ports model
Source: compiled by the author.

The model is based on various classifications, including population, development of marine-sector industries, employment in marine-sector industries, output in marine-sector industries, and the role of coastal regions in global GDP production. Each of these classifications is applied in specific studies focused on the activities, potential, and throughput of seaports. Table 1 presents a universal classification of EU Baltic Sea ports.

The Baltic ports, especially the large and medium-sized ones, have a universal cargo turnover structure. When evaluating the operations of ports in general – such as cargo turnover, passenger turnover, and container turnover – a very interesting specificity emerges: while the ports of the eastern Baltic specialize in handling bulk cargo (both liquid and dry), the ports of the western Baltic focus on general cargo, which accounts for the majority of cargo turnover in Baltic Sea ports.

Table 1. Universal classification of Baltic Sea ports

Classification	Port type	Examples of ports (EU)
1	2	3
Cargo turnover	Large (> 50 million tons)	Gdansk (Poland)
	Medium (10–50 million tons)	Riga (Latvia)
	Small (< 10 million tons)	Haapsalu (Estonia)
Strategic significance	International hub ports	Gdansk (Poland)
	National hub ports	Klaipeda (Lithuania)
	Regional ports	Liepaja (Latvia)
Interaction with other transport modes	Multimodal ports	Port of Gdansk (Poland) – connection with rail and road transport
	Ports with limited interaction	Port of Paldiski (Estonia) – predominantly maritime transport
Technological classification	Ports with digital infrastructure	Ports of Rauma (Finland) and Gavle (Sweden)
	Ports with sustainable practices	Helsinki (Finland)
Geographical location	Seaports	Gdansk (Poland)
	Riverine ports	Riga (Latvia) on the Daugava River
	Lacustrine ports	Vuosaari (Finland) on Lake Saimaa
	Canal ports	Ports on Göta Canal (Sweden)
	Ports of inland water bodies	Narva (Estonia) on Narva River

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cont. **Table 1**

1	2	3
Functional purpose	Commercial ports	Klaipeda (Lithuania)
	Bulk ports	Riga (Latvia)
	Container ports	Gothenburg (Sweden)
	Fishing ports	Liepaja (Latvia)
	Passenger ports	Tallinn (Estonia)
	Military ports	Military Port of Klaipeda (Lithuania)
	Specialized ports	Ventspils (Latvia) – oil port
Degree of accessibility	Perennial operation	Helsinki (Finland)
	Seasonal	Paldiski (Estonia)
Degree of automation	Automated	Gdansk (Poland)
	Non-automated	Kunda (Estonia)

Source: compiled by the author.

RESULTS AND DISCUSSION

The study conducted two separate Pearson correlation analyses to examine the relationship between GDP and cargo turnover of European Union seaports in the Baltic Sea Region.

The first analysis focused on the correlation between GDP and port cargo turnover for individual countries in the region from 2018 to 2022. This approach enabled the assessment of whether a relationship exists between these variables and how they evolved within individual economies during the analyzed period.

The second analysis concentrated on examining the correlation between GDP and port cargo turnover (Tables 2 and 4) in spatial terms, encompassing all countries collectively over specific years. This provided insights into the variation in the strength and direction of the relationship between these variables on a regional scale in the Baltic Sea.

Conducting both analyses was aimed at a more comprehensive study of the interdependence between economic environment and port cargo turnover at both national and regional levels in the Baltic Sea Region's EU countries.

The statistical analysis using the Pearson correlation coefficient showed a differentiation in the strength and direction of the relationship between GDP and seaport cargo turnover in the 8 Baltic Sea countries studied in 2018–2022. In Germany, Denmark and Poland, positive correlations were identified with coefficients of 0.35, 0.57 and 0.94, respectively. This indicates the presence of a positive relationship from weak to strong. Thus, GDP growth contributed

Table 2. GDP of EU Baltic Sea Region countries in 2018–2022 (current price, EUR million)

Countries	2018	2019	2020	2021	2022
Poland	499,004.1	532,504.7	526,147.2	576,382.6	654,594.4
Sweden	470,673.1	476,869.5	480,556.4	540,734.0	562,526.3
Germany	364,584.0	372,150.0	371,790.0	395,580.0	434,374.0
Denmark	302,328.7	309,526.4	311,356.3	342,961.7	380,617.8
Finland	233,462.0	239,858.0	238,038.0	250,923.0	268,645.0
Lithuania	45,515.2	48,959.2	49,873.2	56,478.1	67,399.1
Latvia	29,153.6	30,572.9	30,109.5	33,348.9	38,870.0
Estonia	25,932.2	27,951.0	27,430.0	31,169.0	36,011.1

Source: compiled by the author based on Eurostat data.

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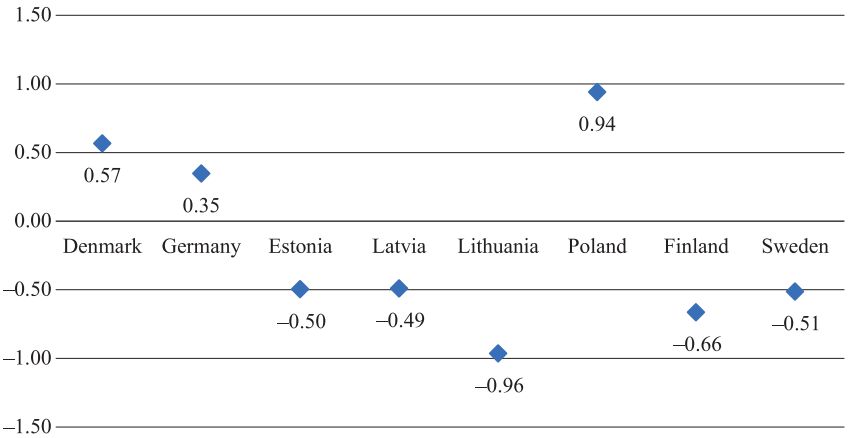

Fig. 2. Pearson correlation coefficients between GDP and seaport cargo turnover in selected Baltic Sea Region countries in 2018–2022

Source: compiled by the author.

to an increase in port turnover. Consequently, it can be assumed that in these countries, economic development during the analyzed period stimulated the activities of seaports (Fig. 2).

However, in some countries of the Baltic Sea Region, notably Estonia, Latvia, Lithuania, Finland, and Sweden, the correlation coefficients ranged from –0.49 to –0.96. These values indicate moderate to strong negative correlations. In these countries, GDP growth was associated with a decrease in port turnover, suggesting that economic development either did not positively influence the port sector or may have had a negative impact on it.

The study thus revealed a distinct divergence in the relationship between the economic environment and port turnover across the Baltic Sea Region. Positive correlations were observed in only three out of the eight countries studied. In the remaining countries, the relationship was inverted, with Lithuania exhibiting the strongest negative correlation. These results indicate that economic growth in the region did not uniformly translate into positive effects on the port sector.

The study aimed to verify the hypothesis of a statistically significant relationship between the GDP of selected Baltic Sea countries and the cargo turnover in their seaports from 2018 to 2022. The Pearson correlation coefficient was employed to measure the strength of the correlation, and the value of the t-test statistic was compared with the critical region for an assumed significance level of $\alpha = 0.05$ with 8 degrees of freedom to verify statistical significance.

The Pearson correlation coefficients obtained suggest the presence of a positive relationship between the examined variables throughout all the analyzed years. The strength of this relationship intensifies from moderate (0.65) in 2018 and 2019, to quite strong in 2020 (0.69), and to strong in the years 2021–2022 (0.77 and 0.80, respectively).

Table 3. Statistical analysis of the correlation between GDP of selected Baltic Sea Region countries and seaport cargo turnover in 2018–2022

	n	α	P_{xy}	t	T	R^2
2018	8	0.5	0.65	2.12	2.454	42.80%
2019	8	0.5	0.65	2.12	2.454	42.90%
2020	8	0.5	0.69	2.34	2.454	47.70%
2021	8	0.5	0.77	2.98	2.454	59.60%
2022	8	0.5	0.80	3.30	2.454	64.50%

Source: compiled by the author.

Nevertheless, only in the last two years did the t-test statistic values surpass the critical threshold (with $\alpha = 0.05$ defining the critical region as (–2.454, 2.454), which substantiates the rejection of the null hypothesis and confirms the statistical significance

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of the relationship at the 0.05 level. In the years 2018–2020, despite increasing Pearson coefficient values, the t-test statistics did not support a definitive conclusion regarding the existence of a statistically significant correlation.

Considering these outcomes, it can be concluded that in the last two years, the variables under study exhibit a statistically significant, positive, and strong correlational relationship.

The total cargo turnover of ports in the Baltic Sea Region for 2022 amounted to 670.019 thousand tons, representing a 2.39% increase over 2021 (654.355 thousand tons). However, compared to 2018 (696.182 thousand tons), cargo turnover decreased by 3.76%. Among the Baltic Sea Region countries, Sweden had the highest cargo turnover in 2022, with 168.181 thousand tons, or 25.11% of the total turnover. This was followed by Poland, with 118.972 thousand tons or 17.76%, and Finland, with 106.566 thousand tons or 15.90%. The most significant growth in cargo turnover in 2022, compared to 2021, was observed in Poland (23.06%) and Latvia (15.21%). At the same time, Poland showed positive dynamics compared to 2018, with a growth rate of 29.60%. Cargo turnover data for the EU Baltic Sea ports are presented in Table 4.

On the other hand, the largest declines in cargo turnover in 2022, compared to 2021, were recorded in Lithuania (18.52%) and Estonia (15.39%). Latvia experienced a significant decrease in turnover, by 27.35% compared to 2018, making it the least stable among the countries considered. It should also be noted that the impact of the COVID-19 pandemic in 2021 was less burdensome than in 2020.

As can be seen from the data (Table 5), Sweden is the key player among the countries considered, with the largest share in 2022 (83.604 thousand tons, or 28.88% of the total general cargo turnover). This country's performance has remained stable over all the years considered, experiencing a slight decrease in 2020 and a minimal change of –0.06% between 2022 and 2021.

Finland and Denmark also demonstrate relative stability, each showing a slight decrease in 2020. Their shares in 2022 amount to 15.43% (44,666 thousand tons) and 14.12% (40,882 thousand tons), respectively. At the same time, Finland shows a positive trend, with an increase in indicators of 1.04% between 2022 and 2021, while Denmark shows an increase of 0.89%.

The situations in Germany and Poland differ. Germany's figures decreased in 2020 but recovered in 2021; however, they decreased again in 2022 by 6.10%. Poland maintains relative stability, with a minimal decrease of 0.17% between 2022 and 2021. Lithuania stands out among the other countries, showing the highest growth in indicators of 12.22% between 2022 and 2021. In Estonia, there is a strong decline in indicators, amounting to 24.61% over the same period. Latvia shows moderate growth, at 3.29%.

Of particular interest is the volume of cargo transshipment in the five largest EU ports in the Baltic Sea Region (Fig. 3). The Port of Gdansk shows the most pronounced positive dynamics, with a growth rate

Table 4. Cargo turnover of EU Baltic Sea ports in 2018–2022 (thousand tons)

Countries	2018	2019	2020	2021	2022	Average	2022/2021	2022/2018	Share 2022
Sweden	179,042	169,792	167,594	168,181	168,251	170,572	0.04%	-6.03%	25.11%
Poland	91,798	93,864	88,520	96,680	118,972	97,967	23.06%	29.60%	17.76%
Finland	118,311	121,567	109,948	103,727	106,566	112,024	2.74%	-9.93%	15.90%
Denmark	95,989	93,727	91,271	94,255	97,196	94,488	3.12%	1.26%	14.51%
Germany	56,480	56,844	54,052	60,626	57,080	57,016	-5.85%	1.06%	8.52%
Latvia	66,175	62,380	44,928	41,731	48,078	52,658	15.21%	-27.35%	7.18%
Lithuania	52,463	52,244	51,529	49,751	40,537	49,305	-18.52%	-22.73%	6.05%
Estonia	35,924	37,690	37,688	39,404	33,339	36,809	-15.39%	-7.20%	4.98%
Total	696,182	688,108	645,530	654,355	**670,019**	**670,839**	**2.39%**	**-3.76%**	-

Source: compiled by the author based on Baltic Transport Journal (2020, 2021, 2022, 2023).

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Table 5. General cargo turnover of EU Baltic Sea ports in 2018–2022 (thousand tons)

Countries	2018	2019	2020	2021	2022	Average	2022/2021	2022/2018	Share 2022
Sweden	84,923	83,419	78,979	83,652	83,604	82,915	-0.06%	-1.55%	28.88%
Finland	49,212	49,207	43,713	44,207	44,666	46,201	1.04%	-9.24%	15.43%
Denmark	38,551	37,903	37,850	40,520	40,882	39,141	0.89%	6.05%	14.12%
Germany	40,229	39,474	37,446	43,297	40,656	40,220	-6.10%	1.06%	14.04%
Poland	37,841	37,312	35,640	38,520	38,453	37,553	-0.17%	1.62%	13.28%
Lithuania	12,640	11,636	10,949	12,410	13,926	12,312	12.22%	10.17%	4.81%
Latvia	15,517	12,406	12,362	13,352	13,791	13,486	3.29%	-11.12%	4.76%
Estonia	14,274	13,440	12,015	17,984	13,559	14,254	-24.61%	-5.01%	4.68%
Total	**293,187**	**284,797**	**268,954**	**293,942**	**289,537**	**286,083**	**-1.50%**	**-1.24%**	–

Source: compiled by the author based on Baltic Transport Journal (2020, 2021, 2022, 2023).

of 30.8%, especially given the significant increase in 2022 to 68,220 thousand tons. This growth was associated with the import of energy raw materials from abroad, due to the imposition of sanctions against Russia. Additionally, over the entire analyzed period, the ports of Szczecin – Świnoujście exhibited moderate growth of 20.6%, which may indicate a gradual development of port operations. It should also be noted that the transshipment volume in all Polish ports in 2022 was influenced by the handling of Ukrainian exports; ore and grain from Ukraine were transshipped at the Ports of Gdansk, Gdynia, and Szczecin – Świnoujście.

The opportunities for container terminal handling play a significant role in both the development and competitiveness of ports, as illustrated in Figure 4. Between 2019 and 2022, the five largest container ports in the EU's Baltic Sea Region exhibited divergent trends in container handling volumes. The average handling volume increased from 1,006,930 TEU in 2019 to 1,135,680 TEU in 2022, representing an increase of 18.87%. The Port of Klaipeda stands out in particular, showing a growth rate of 57.17% in 2022 compared to 2021, and 49.07% compared to 2019. These high container-handling figures are attributable

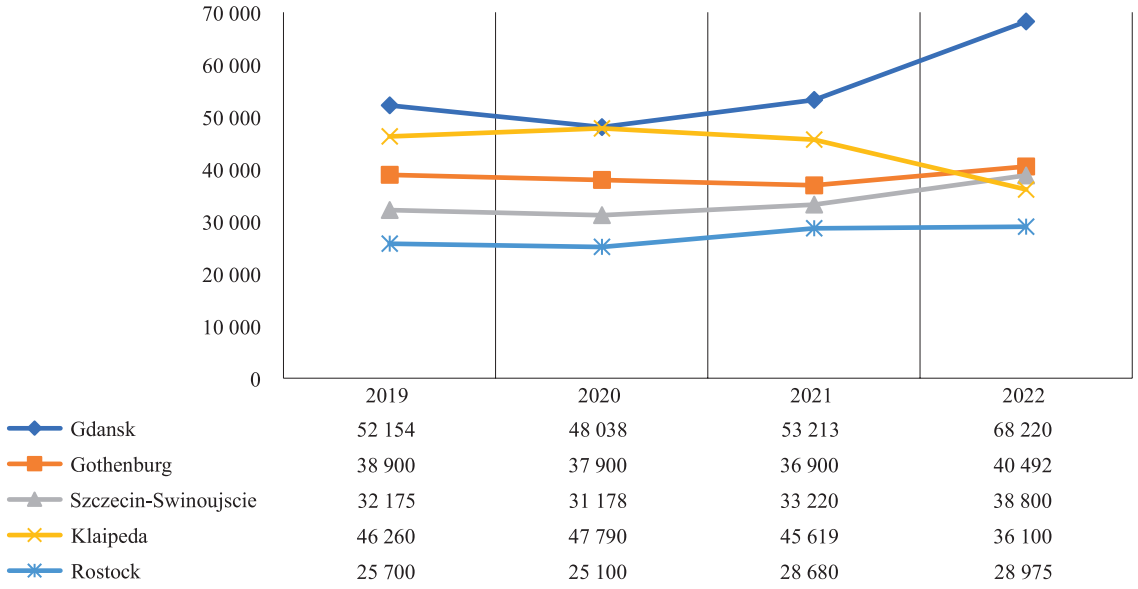

Fig. 3. Transshipment volumes in the five largest EU ports in the Baltic Sea in 2019–2022 (thousand tons)
Source: compiled by the authors based on Port Monitor (2022, 2023); Główny Urząd Statystyczny (2022).

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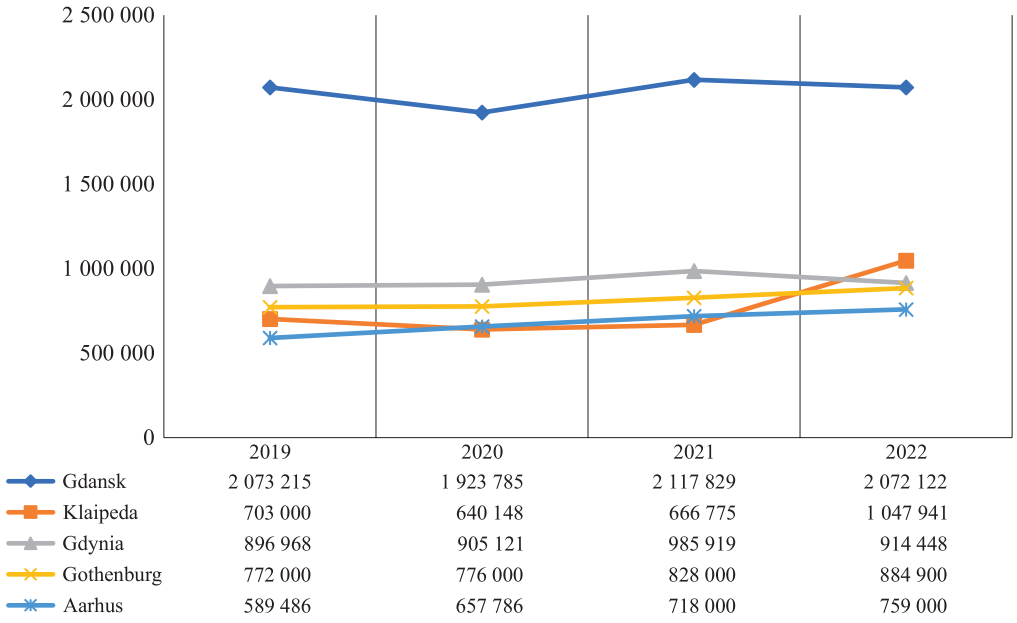

	2019	2020	2021	2022
Gdansk	2 073 215	1 923 785	2 117 829	2 072 122
Klaipeda	703 000	640 148	666 775	1 047 941
Gdynia	896 968	905 121	985 919	914 448
Gothenburg	772 000	776 000	828 000	884 900
Aarhus	589 486	657 786	718 000	759 000

Fig. 4. Handling volumes at the five largest container ports in the EU Baltic Sea in 2019–2022 (TEU)
Source: compiled by the authors based on Port Monitor (2022, 2023); Główny Urząd Statystyczny (2022).

to the launch of new routes, including the MSC service (ScanBaltic – US East Coast) that operates between Klaipeda, Gdynia, Gothenburg, and New York. While the ports of Gdansk and Gdynia experienced slight decreases and increases, respectively, the ports of Gothenburg and Aarhus demonstrated moderate growth.

Currently, there is a need to facilitate increased business activity for the innovative and investment-driven development of coastal regions, as well as the expansion of their hinterlands. Even now, most large and major ports are becoming advanced development territories due to the successful operation of industrial and manufacturing enterprises within the ports and the expansion of stevedoring and logistics capabilities. The prerequisites for establishing industrial zones in these areas include modern trends and specific developments in the global economy, as well as the presence of a highly efficient logistics infrastructure built on the latest innovative developments and ongoing research.

CONCLUSIONS

The new challenges and shifts in economic activity under crisis conditions compel us to reevaluate the environment in which BSR seaports operate. One of the most pressing issues today is whether the functional system – comprising the transport infrastructure in general and seaports in particular – will be able to handle increasing cargo traffic volumes. The primary conclusion is that it is essential to plan the future development of seaports based on strategic scenarios and the identification of shared development priorities.

The research conducted revealed a statistically significant positive correlation between GDP and port cargo turnover in the Baltic Sea Region. This empirical evidence supports the hypothesized positive relationship between economic growth and the cargo turnover of EU Baltic Sea ports (H1).

Despite the challenges posed by the COVID-19 pandemic and the evolving geopolitical landscape,

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Baltic Sea ports, including those in Poland, have significantly strengthened their roles as key logistics hubs in the region (H2). This assertion is supported by the analyzed indicators, such as increased cargo turnover and enhanced container handling capacities. Notably, Polish ports, particularly the Port of Gdansk, have exhibited dynamic growth. They serve as hubs connecting maritime routes with land transport.

At the same time, Baltic ports demonstrate high activity in implementing innovations to meet future challenges. They have implemented digital solutions, such as process automation, as well as environmental measures like the use of alternative fuels. They also actively participate in international cooperation aimed at exchanging experience and knowledge.

The analysis has also revealed the need for further sustainable development of Baltic ports. Particularly important are: improving the quality of services provided, developing transport infrastructure, integration with infrastructure, and increasing resilience to crises. Strategic planning and investments in new technologies and infrastructure are of key importance.

There are challenges in ensuring the balanced development of port functions, which are integral to the development of the maritime zone. Primarily, this involves the transport and technological function, closely linked to port and industrial complexes. Recently, the location of many industrial enterprises in the port hinterlands (the territory adjacent to the port) has led to issues concerning the availability of modern utility fleets, approach roads, railways, and coordinated tariff policies. To address these challenges, a high degree of coordination is required among organizations and institutions involved in the balanced development of seaports. These include organizations like ESPO (The European Sea Ports Organisation), local governments, business representatives, and other economic agents.

Despite facing serious crises, the ambitious goals, objectives, and implementation mechanisms of the EU's Blue Policy in the field of maritime transport and seaport development still need to be addressed. In-depth, comprehensive research is needed, along with the creation of a new maritime policy and Poland's "Program for the Development of Polish Seaports until 2030"[2]. This program aims to establish Poland as a major player in transportation turnover in the North-South and West-East directions and to redirect cargo from the Black Sea to the Baltic-Atlantic direction.

A significant qualitative improvement in the functioning of BSR seaports, as well as the resolution of existing problems in their development, creates conditions for balanced and sustainable growth in the EU's Blue Policy overall. The establishment of the main priorities and mechanisms for achieving set goals through research will elevate the quality of services provided by the Baltic Sea port sector. This will elevate it in terms of ensuring European foreign trade flows and enhancing the competitiveness of BSR ports on the international stage. The methods and analytical tools proposed in this article can be used for further comprehensive research and strategic planning regarding Polish seaports. An in-depth analysis of the activities of Polish ports using the proposed tools will enable strategic planning for their sustainable development, considering new political and economic realities.

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[2] The need to adopt a program arises from the absence of a comprehensive government document addressing port development for several years. The most recent document of this kind was the 'Strategy for the Development of Seaports until 2015'. The primary aim of the program is to continually strengthen Polish seaports as leaders among Baltic Sea ports. These ports should function as key nodes in global supply chains for Central and Eastern Europe and contribute to the country's more active socio-economic development.

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