Port performance evaluation. Case study: Ports in the Black Sea basin

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Abstract. Water transport is one of the essential elements of international economic exchanges. Over 85% of international trade is achieved through this mode of transport, which remains the cheapest and at the same time an indispensable factor for meeting demand for goods and services. The development of a country's economy, which is open to the sea, requires, among other things, the stimulation of maritime and river transport and, implicitly, of port activity. Improving port system performance reduces transport costs, and indirectly can ensure increased competitiveness of the economic sectors at the level achieved by other EU countries. This is only possible through innovative management to ensure the identification and implementation of quality improvement solutions and optimization of port logistics processes. The paper summarizes the results of the research on: the main features of port services, the quality of port services, port system components and port competitiveness. The comparative analysis of port development priorities was based on a set of criteria accepted internationally. The research carried out included both the highly developed ports and those in the average performance area. The conclusions of the paper highlight several relevant aspects that could be detailed in order to find solutions for increasing port competitiveness.

1. Introduction

Ensuring a growing volume of goods transported by water is made by larger and more specialized ships that are subject to strong pressure to adapt to the new international trade performance requirements. Literature reveal that one of the medium and long-term priority objectives for port performance is associated with increasing the efficiency of port subsystems: cargo handling and transshipment, indoor transport, storage, delivery and reception, Figure 1.
In this context, an analysis of the overall operating framework of the port system becomes a vital requirement for achieving a port-performance-enhancing strategy that will provide the port with a competitive position within the international logistics chain. Thus, the port has become, from the physical place where the cargo is transferred from the ship to the quay and vice versa, the logistics center that provides not only cargo handling operations but also a series of complex services provided to ships and cargo, such as: packaging and marking of goods, container repairs and industrial processing activities (such as petroleum refining), ship repair, bunkers etc. Step by step modern ports have become dynamic knots in international production and distribution networks over the last 20 years [2].

Port as a logistics center is a concept closely linked to the development of a country's foreign trade and is therefore associated with the expansion of the processing industry with added value for export [3]. In most cases, by increasing port productivity, maintenance of operating costs at lower levels is ensured and continuous management improvement for all subsystems of the transfer system transforms the port into an economic system that boosts economic growth at regional and national level.

The globalization process makes ports the main points of access to the international commerce network. That is why the world economy needs well-developed and efficient ports according to international standards. In the case of the European Union, while some of the ports are among the best performing in the world (Rotterdam, Antwerp and Hamburg), others have consistently recorded lower performance for some time. Lack of performance has become permanent, turning into a structural decline that slows regional economies. Consequently, the structural performance gap reduces the options available to maritime and logistics operators at international level. It is important to note that in 2011 19.8% of the goods arriving in Europe by sea crossed the three ports mentioned above. In 2016 this percentage increased to 20.3% [4].

The domino effect is anticipated in numerous scientific papers. In the case of high-performance ports in the western part of Europe, there is congestion and "suffocation" of the hinterland area with major repercussions on road and rail traffic and implicitly on increasing discomfort for citizens in these regions. Given that freight volumes are projected to reach more than 5.5 billion tonnes of freight by 2030 compared to 3.9 billion tonnes in 2012, it will be necessary that all ports in the trans-European network to contribute in order to cope this growth [5].

![Figure 2. Main ports in the Black Sea Basin](image)

Given that the ports in Western Europe are overburdened, statistics show that only 2.5% of international maritime trade has taken place in the Black Sea ports over the last 10 years [6]. This information shows that the advantages offered by the geographical opening of this area and its connectivity with transport routes in Europe, Asia and Africa are not yet capitalized, Figure 2. It is to be expected that in the medium and long term the freight volumes that will transit the ports in the Black Sea basin, such as Varna and Burgas (Bulgaria), Trabzon (Turkey), Poti and Batumi (Georgia) and Novorossiysk (Russia) to grow.
The analysis shows that these ports have experienced important economic and institutional changes, the globalization process, structural changes in logistics and distribution networks, as well as the fierce competition between them that influences their development. At the same time, countries in the Black Sea region have major plans to extend port and terminal specialization for certain types of freight, especially bulk and container cargo [7].

The development of ports in this area could lead to new models of regional development of port networks and other dynamics of trade relations. Given that the port has become a key component, dynamically integrated into Supply Chain Management, the authors highlight the need for a new approach to the issue of the general framework of the port system, whose international dimension is also recognized in European documents. Starting from the existing realities in the Black Sea basin, in the case of the provision of goods transhipment services there are unfair competition practices from the Black Sea ports [8]. Therefore, medium and long term sustainable development of this geographical area will not be possible without closer cooperation with neighboring countries, with a goal to achieve a sustainable transport system which will be beneficial for all EU partners.

Under these circumstances, to identify the port development priorities in the Black Sea basin, an analysis of the overall port operation framework and port facility and performance reporting is required based on a set of internationally accepted criteria.

The research aims determining a set of Priority Indicators for Port Development (PIPD) and assessing them for ports in the Black Sea basin. Under these conditions, 15 European ports were identified: developed European ports as reference models (Rotterdam, Antwerp, Hamburg), average performance ports (Marseilles, Algeciras and Valencia, stating that in EU records also the port of Constanta is in this area) and the main ports in the Black Sea basin.

2. Research methodology and results
An important concept in scientific research is that of research methodology, which describes the methods used and the steps taken on the road to knowledge. In the scientific approach, the authors combined a set of qualitative and quantitative methods to obtain a set of priority indicators for port development.

The conceptual framework for this research was structured in two parts. The first part summarizes the information resulting from the analysis of the literature regarding the priorities of the development of the port activity. The results were centralized in the form of a set of 10 indicators, which can ensure the assessment of the level of development of a port. The proposed indicators are: the advantages of geographic positioning, the quality of hinterland connections, the availability and efficiency of port services provided to goods and ships, the price of port products, socio-economic sustainability, port infrastructure, information and communication systems in port activity, flexibility and adaptability to changes in international trade. The literature with the highest relevance for the problems related to the development of the port system were selected, Table 1.

| Identified indicator                                       | Code | Reference             |
|-----------------------------------------------------------|------|-----------------------|
| Geographic positioning                                    | I1   | [9, 10, 11]           |
| Quality of transport connections with hinterland          | I2   | [12, 13, 14]          |
| The availability and efficiency of port services provided to goods | I3   | [2, 15, 16, 17, 18]   |
| The availability and efficiency of port services provided to ships | I4   | [2, 19, 20]           |
| Prices of port products                                  | I5   | [2, 20]               |
| Socio-economic sustainability                            | I6   | [21, 22]              |
| Port infrastructure                                      | I7   | [1, 23, 24]           |
| Informational and communication systems in port activity | I8   | [2, 25, 26]           |
| The human resource involved in port activity             | I9   | [22, 27, 28]          |
| Flexibility and adaptability to changes in international trade | I10  | [29, 30, 31]          |
From the selected references, the main characteristics that resulted for each indicator were summarized and they were centralized in Table 2. The selection of characteristics was reported to the port activity framework and to the best practices implemented by the developed European ports, considered in the paper as reference models (each indicator having the maximum performance level for them).

For the second part of the research method, the identified indicators, along with their characteristics, formed the basis of the implementation of a port performance assessment questionnaire (PPAQ). The questionnaire was discussed and analyzed in exploratory interviews (expert group method) with the most relevant stakeholders in the maritime industry in Romania, representatives of: shipping companies, terminal operators, shippers, logistics groups and port administration. In the process of selecting the stakeholders, it was considered that the interviewees had connections through their activities with the ports and freight forwarding companies in central and western Europe as well as with ports and companies from the countries in the Black Sea basin. Individuals selected to participate in exploratory interviews have a high level of expertise and are familiar with port and port system issues.

Table 2. Details of priority indicators for port development

| Indicator | Characteristics of priority indicators for port development |
|-----------|-----------------------------------------------------------|
| I1        | A port located at the confluence of the major maritime routes and benefiting from favorable physical conditions (natural embankment, a area protected from the marine environment etc.) has a competitive advantage over other seaports. Examples of such ports: Singapore, Antwerp, Rotterdam, Hamburg, Constanta. Port activity is dependent on the quality of hinterland transport connections. These links, which ensure the relationship between the exporter and the consignee, are decisive for the international freight forwarding. A high quality level of hinterland connections contributes to the integration of services in the freight logistics chain. |
| I2        | The main stakeholders involved in the work of a port are constantly represented by shipowners and shipboard operators (chargers) who subcontract services to maritime and transit agents. The services provided to the goods are diverse, of high importance for the logistics chain. The services provided to ships must provide: maneuvers for arrival / departure from the operational berth, binding / unbinding, power / water / fuel supply. Given the importance of total port staying time on its economic performance, these services must be delivered in time with maximum efficiency. The port, as an integrated system in the international logistics chain, must develop a commercial strategy tailored to regional and international competition. Each time the final price to be paid for the port product by importers / exporters is determined as the sum of the costs associated with the services provided by the shipping, transit and other port system components. For this reason, port administration, shipping agents, charterers and other stakeholders must ensure competitive prices in the maritime market. Socio-economic sustainability refers to solutions that prove to be difficult to control for a particular geographic area. Practice shows that unstable situations are mainly generated by political and military instability, economic boycott, incoherent and changing administrative policies, macroeconomic imbalances. Ports are socio-technical systems with a high degree of complexity, with a very important role in the international commodity exchange as a link for all forms of transport. Under these circumstances, port infrastructure must provide, through port systems and equipment, quality services for ships and freight. In the same context, ports are used as warehouses or distribution centers where value-added activities are carried out, such as labeling, packaging, packing, palletizing. The permanent connection to the international
logistics chain often requires retechnology, the implementation of new and innovative solutions for all the components of the port system. Informational and communication systems have an increasingly important role in ensuring and maintaining an efficient management of commodity flows and relationships with partner organizations. The e-maritime concept is increasingly in port activity and in the activities of shipping companies. The port industry in recent years has focused on implementing advanced, high-productivity technological solutions that are less dependent on human effort and the immediate consequence is the rapid adaptation of professional training to these transformations. In recent studies, port personnel is grouped into two main categories: port workers and port executives. The port workers category includes stevedores, checkers, tallymen and clerical staff; executive staff includes supervisors of operations performed in the terminal. Special training programs are required for each category.

Structural changes in international trade are permanent, generating significant quantitative and qualitative mutations in port activity. Flexible management in port administration, quick adaptation of port community members to change will be the most used tools for achieving port performance.

In the initial exploratory interview, the set of indicators identified in Table 1 that was converted into a set of Port Performance Measurement Indicators (PI) was validated and the assessment questionnaire corrected on the basis of the comments received. In the exploratory interviews that followed, the questionnaire was completed by all the interested stakeholders. The interviewees used information from various sources in which statistical data, technical information, annual activity reports on selected ports for analysis were presented. The performance level for each indicator (PI) was measured using a five-point Likert scale ranging from 5 - excellent; 4- very good; 3- good; 2 - satisfactory; 1 - mediocre. Each indicator was evaluated for each port and the results are shown in Table 3.

As mentioned above, the selection of features was reported to the port activity framework and the good practices implemented by the developed European ports, considered in the paper as reference models (level 5 on the Likert scale), P* port. The average performance indicator PI\text{med} shows the level of development of each port, level relative to the European reference model.

Table 3. Setting the indicators performance level of port development

| Performance Indicator | Odessa | Illichivsk | Constanța | Varna | Burgas | Trabzon | Poti | Batumi | Novorosisk | P* |
|-----------------------|--------|-----------|-----------|-------|--------|---------|------|--------|------------|----|
| PI1                   | 5.0    | 5.0       | 5.0       | 5.0   | 5.0    | 5.0     | 5.0  | 4.8    | 5.0        | 5.0 |
| PI2                   | 3.3    | 2.9       | 3.4       | 3.5   | 3.5    | 3.4     | 3.2  | 3.0    | 3.5        | 5.0 |
| PI3                   | 3.0    | 2.8       | 3.8       | 3.3   | 3.3    | 3.6     | 2.8  | 2.9    | 3.7        | 5.0 |
| PI4                   | 3.4    | 2.1       | 3.9       | 3.4   | 3.4    | 3.7     | 2.8  | 2.7    | 3.8        | 5.0 |
| PI5                   | 3.3    | 2.2       | 3.7       | 3.2   | 3.2    | 3.8     | 2.5  | 2.7    | 3.6        | 4.6 |
| PI6                   | 2.7    | 2.7       | 3.8       | 3.4   | 3.4    | 3.2     | 2.6  | 2.5    | 3.7        | 5.0 |
| PI7                   | 3.3    | 3.0       | 3.6       | 3.3   | 3.3    | 3.6     | 3.0  | 3.1    | 3.5        | 5.0 |
| PI8                   | 3.9    | 3.3       | 4.2       | 4.0   | 4.0    | 3.9     | 3.3  | 3.2    | 4.0        | 5.0 |
| PI9                   | 3.3    | 3.1       | 3.4       | 3.3   | 3.3    | 3.4     | 3.1  | 3.4    | 3.4        | 5.0 |
| PI10                  | 2.9    | 2.9       | 3.5       | 3.3   | 3.3    | 3.3     | 2.9  | 2.7    | 3.3        | 5.0 |
| PI\text{med}          | 3.41   | 3.00      | 4.02      | 3.57  | 3.57   | 3.69    | 3.09 | 3.1    | 3.75       | 4.96 |

The results presented in Table 3 show a major difference between the ports in the Black Sea basin, PI\text{med}=3.118 and the reference ports P*, PI\text{med}=4.96. Of the ports in this area, Constanța port has PI\text{med}=4.02, followed closely by Novorosisk port PI\text{med}=3.75. Port of Constanța has the advantage of its geographic position, at the intersection of the commercial routes linking the Central and Eastern
European markets with Transcaucasia, Central Asia and the Far East. This opportunity could be redeemed by providing a better connection with the hinterland. The main competitor of the port of Constanta is the port of Novorosisk. It is part of a group of ports alongside the Primorsk harbor, the Baltic Sea and the Baltisk harbor in the Kaliningrad region. This association can be an alternative route to North and Western Europe to the Western Black Sea ports. The analysis can be developed by a detailed research of each performance indicator.

3. Conclusions

Research shows that ports can play a decisive role in economic recovery and increased long-term competitiveness of a country or geographic economy. The paper proposes a set of priority indicators for port development and an assessment methodology through which port performance can be determined. The assessment methodology was applied to the representative ports of the Black Sea Basin in relation to a reference model corresponding to the highly developed European ports.

The results obtained have highlighted the performance of these ports in terms of the advantages of geographic positioning, the quality of transport connections with hinterland, the availability and efficiency of port services provided to goods and ships, the price of port products, socio-economic sustainability, port infrastructure, the quality of the human resource involved in port activity, flexibility and adaptability to changes in international trade. The obtained results highlight the structural disparities between these ports and the port reference model. The research can be continued in the following directions: the detail of each identified indicator on the types of terminals and sorted sorts of cargoes, the comparative analysis of port performance for various port entities, the identification of investment opportunities in certain sectors of port activity, the identification of training needs in certain domain/subdomain of port activity.

In conclusion, a correct assessment of a port activity is made when all the factors that influence its activity are considered. Port performance indicators should take account of these factors and reflect: how port facilities and resources are used to highlight the effect of corrective actions to prevent losses or improve operations; the way in which intensive activity factors are assessed so that planners can decide when and where additional resources are needed; the quality of services provided to shippers, carriers and other users of the port.

References

[1] Nicolae F., Ristea, M., Cotorcea A., Nistor, F., 2015. The Relationship Between Port Logistics and Global Logistics Performance. Scientific Bulletin" Mircea cel Batran" Naval Academy, 18(1), ISSN 1843-6749, pp. 83-88.
[2] Talley, W. K. (2017). Port economics. Routledge.
[3] Mangan, J., Lalwani, C., & Fynes, B. (2008). Port-centric logistics. The International Journal of Logistics Management, 19(1), 29-41.
[4] Review of Maritime Transport (Series), 2012-2017.
[5] European Comission, (2017). Study on differentiated port infrastructure charges to promote environmentally friendly maritime transport activities and sustainable transportation.
[6] Ducruet, C. (Ed.). (2017). Advances in Shipping Data Analysis and Modeling: Tracking and Mapping Maritime Flows in the Age of Big Data.
[7] Grushevska, K., & Notteboom, T. (2014). An economic and institutional analysis of multi-port gateway regions in the Black Sea Basin. Journal of International Logistics and Trade, 12(2), 3.
[8] European Comission. (2014). Ports: an engine for EU growth.
[9] Chou, C. C. (2010). Application of FMCDM model to selecting the hub location in the marine transportation: A case study in southeastern Asia. Mathematical and Computer Modelling, 51(5-6), 791-801.
[10] Jacobs, W., Ducruet, C., & De Langen, P. (2010). Integrating world cities into production networks: the case of port cities. *Global networks, 10*(1), 92-113.

[11] Tongzon, J. L. (2009). Port choice and freight forwarders. *Transportation Research Part E: Logistics and Transportation Review, 45*(1), 186-195.

[12] Konings, R., Kreutzberger, E., & Maraš, V. (2013). Major considerations in developing a hub-and-spoke network to improve the cost performance of container barge transport in the hinterland: the case of the port of Rotterdam. *Journal of Transport Geography, 29*, 63-73.

[13] Zondeg, B., airc, P., Gützkow, P., & de Jong, G. (2010). Port competition modeling including maritime, port, and hinterland characteristics. *Maritime Policy & Management, 37*(3), 179-194.

[14] Aronietis, R., Markianidou, P., Meersman, H., Pauwels, T., Pirenne, M., Van de Voorde, E., & Verhetsel, A. (2010). Some effects of hinterland infrastructure pricing on port competitiveness: case of Antwerp. In *12th World Conference on Transport Research*. Lisboa.

[15] Thai, V. V. (2016). The impact of port service quality on customer satisfaction: The case of Singapore. *Maritime Economics & Logistics, 18*(4), 458-475.

[16] Yeo, G. T., Ng, A. K., Lee, P. T. W., & Yang, Z. (2014). Modelling port choice in an uncertain environment. *Maritime Policy & Management, 41*(3), 251-267.

[17] Tang, L. C., Low, J. M., & Lam, S. W. (2011). Understanding port choice behavior—a network perspective. *Networks and Spatial Economics, 11*(1), 65-82.

[18] Wu, Y. C. J., & Goh, M. (2010). Container port efficiency in emerging and more advanced markets. *Transportation Research Part E: Logistics and Transportation Review, 46*(6), 1030-1042.

[19] Parise, G., Parise, L., Martirano, L., Chavdarin, P. B., Su, C. L., & Ferrante, A. (2016). Wide port and business energy management: port facilities, electrical power distribution. *IEEE Transactions on Industry Applications, 52*(1), 18-24.

[20] Esmer, S., Nguyen, H. O., Bandara, Y. M., & Yeni, K. (2016). Non-price competition in the port sector: A case study of ports in Turkey. *The Asian Journal of Shipping and Logistics, 32*(1), 3-11.

[21] Van den Berg, H. (2016). Economic growth and development. World Scientific Publishing Company.

[22] Rodrigue, J. P., Comtois, C., & Slack, B. (2016). The geography of transport systems. *Taylor & Francis*.

[23] Pavlic, B., Cepak, F., Sucic, B., Peckaj, M., & Kandus, B. (2014). Sustainable port infrastructure, practical implementation of the green port concept. *Thermal Science, 18*(3), 935-948.

[24] Haralambides, H. E. (2002). Competition, excess capacity, and the pricing of port infrastructure. *International Journal of Maritime Economics, 4*(4), 323-347.

[25] Alderton, P., & Saieva, G. (2013). Port management and operations. *Taylor & Francis*.

[26] Mondragon, A. E. C., Lalwani, C. S., Mondragon, E. S. C., Mondragon, C. E. C., & Pawar, K. S. (2012). Intelligent transport systems in multimodal logistics: A case of role and contribution through wireless vehicular networks in a sea port location. *International Journal of Production Economics, 137*(1), 165-175.

[27] Nicolae F., Rosen I., Nistor F., Cotorcea A., (2017). The relations between the port business framework and the qualified manpower competencies – Literature review and proposed guidelines. *Mircea cel Batran Naval Academy Scientific Bulletin, 18*(1), ISSN 1843-6749, pp. 83-88.

[28] McConnell, M. L. (2011). The Maritime Labour Convention, 2006 - Reflections on challenges for flag State implementation. *WMU Journal of Maritime Affairs, 10*(2), 127.

[29] Tanfja, P. (2013). The flexible port. Doctoral thesis

[30] Pantouvakis, A., & Dimas, A. (2013). The role of corporate agility and perceived price on the service quality–customer satisfaction link: some preliminary evidence from the port industry. *International Journal of Shipping and Transport Logistics, 5*(4-5), 412-431.

[31] Makris, S., Zoupas, P., & Chryssoulis, G. (2011). Supply chain control logic for enabling adaptability under uncertainty. *International Journal of Production Research, 49*(1), 121-137.