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Maritime Container Terminal Process Maturity: A Methodological Approach and Empirical Evidence

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Abstract:

Purpose: *The study aims to determine and evaluate the process maturity of Polish maritime container terminals. The research was conducted on the example of three medium-sized Polish maritime container terminals.*
Methodology: *A few research methods were applied, literature review, questionnaire method, comparative analysis, and process maturity model for maritime container terminals which was specially developed by the authors for this study.*
Findings: *Conducted research implies that the three biggest Polish maritime container terminals are considered as mature enough in the context of their processes. In the adopted methodology, the two examined terminals are at the highest level of process maturity, which implies that processes are continuously improved and developed. Within this group there are merely slight differences in the received points – the CT1 is considered the most mature in the context of processes ahead of CT2. However, CT3 is well below the level of its competitors The differences reflect not only their unequal market position but also their different approaches to process management strategies.*
Practical implications: *The results of the study could be considered an interesting source of information for maritime container terminal operators as well as their direct and indirect customers, i.e. container ship operators, maritime forwarders, and shippers. This concept can also become a significant part of a comprehensive assessment of the quality of container terminal services and their current and potential competitiveness, enabling the ranking of these intermodal transport nodes in terms of logistics efficiency.*
Originality value: *This research is the first that attempted to develop the process maturity model for maritime container terminals and verified empirically the process maturity level of Polish maritime container terminals. Moreover, such a model could be used to compare and enhance the process maturity within the logistics supply chains by their operators.*

Keywords: *Process maturity model, maritime container terminal, multidimensional model of process maturity assessment for maritime container terminals.*

JEL classification: *O31, M16, R49.*

Paper type: *Research article.*

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1. Introduction

Maritime container terminals as well developed multimodal transport nodes are not only vital intermodal transport hubs but also crucial links in the global logistics supply chains. Due to their special transport nature and numerous logistic functions performed in the supply chain, on the one hand, they are very susceptible to any disruptions in the logistics supply chains, and on the other hand, they can generate various kinds of disruptions themselves (Grzelakowski, 2021; Notteboom *et al.*, 2021). Any disruptions that arise in sea container terminals are quickly transferred to the remaining links of the global supply chain since the container terminals' processes which should be perfectly coordinated within such logistics hubs, are usually closely integrated with other logistic processes carried out in subsequent links of the supply chain (Grzelakowski, 2022; Charłampowicz, 2021; Charłampowicz and Mańkowski, 2022).

Therefore, to avoid disruptions to the efficient servicing of both container vessels and land means of transport as well as handling of containers, it is necessary to ensure appropriate operational efficiency and reliability, i.e., in a broader sense the highest possible quality of all processes performed in the container terminals.

The quality of processes carried out in container terminals, perceived in terms of their maturity levels, determines the attractiveness and competitiveness of such logistics hubs. Therefore, process maturity is becoming nowadays one of the basic problems in the field of optimization of container terminal operation and management. Process maturity that can be measured indicates how close an evolving business process in a container terminal is to reaching a state of required and expected completeness as well as the capability of continual improvement through qualitative measures and feedback. Thus, for processes to be mature, it has to be complete in their usefulness, automated, reliable in information, and continuously improving.

Recognizing the process maturity of the container terminals both from a theoretical and practical point of view as a vital issue in creating their efficient medium and long-term development strategies, oriented towards increasing their market share and acquiring higher value-added, requires, however, not only a precise clarification of this concept but also developing reliable methods of its assessment. Therefore, the authors of this paper made an attempt to determine and evaluate the process maturity of sea container terminals, based on the example of Polish medium-sized terminals.

2. Research Methodology

In the literature, much place has been devoted to the business process maturity models, where mostly the five or six levels of process maturity have been presented (Becker *et al.*, 2009; Sliż, 2018; Tarhan *et al.*, 2016; van Looy *et al.*, 2011). Organizations at the lowest level of process maturity are only managing processes in

an ad hoc manner (Lee *et al.*, 2007). Moreover, the results of the processes are not identified (El Emam and Birk, 2000). Entities qualified on the highest level of process maturity are characterized by continuous process improvement (Lee *et al.*, 2007; El Emam and Birk, 2000).

Capturing the process maturity level of the maritime container terminal is possible only when a proper and suitable tool is developed. The maritime container terminals are globally homogeneous entities with similar functions, aims, and processes. Moreover, container terminals are entities operating within the framework of specific rules and corporate governance occurring in the global sphere (Charlampowicz, 2019; Farrell, 2012; Notteboom and Rodrigue, 2012), therefore it can be stated that processes are identified, formalized, and measured.

Based on the proposed in the literature business process maturity models (Becker *et al.*, 2009; Tarhan *et al.*, 2016) it is possible to develop a suitable model for process maturity evaluation dedicated to the maritime container terminals, containing four levels, where the lowest level of maturity (L0) would be connected with the identification of processes and the highest (L3) would be dedicated to the continuous improvement of processes.

The proposed model of Multidimensional Model of Process Maturity Assessment for Maritime Container Terminals (MMPMCM) has been designed with division into levels and dimensions. For each level, dimensions allowing for a long-term and short-term assessment of the organization's process maturity were adopted, where symbol "-" meant the long-term atrophy, symbol "+" meant long-term development, and no additional symbol meant stagnation (Sliż, 2018).

Table 1. *Maritime container terminal process maturity levels.*

Level	Dimension	Characteristics
Level 3 - Improvement of processes	L3 A+	The organization shows exceptional maturity in the area of process improvement.
	L3 A	High organization ability to improve processes thanks to the use of modern management methods. The terminal manages the impact of its activities on the natural environment not only in terms of mega-processes and main processes. All employees of the organization are initiators and stimulators of changes and improvements.
	L3 A-	No long-term improvement strategy for all processes. Customer requirements are the driver of changes. Knowledge is treated as a key resource, and the organization, by supporting its employees, causes them to initiate internal training to transfer the acquired knowledge and/or skills.
Level 2 – Management of	L2 B+	Measured processes are managed, and mainly mega-processes are improved. Training is carried out in

processes		response to the forecast changes in the market, moreover, the organization pays more attention to supporting and accelerating the development of employees, e.g. by referring them to postgraduate or MBA studies.
	L2 B	Within the organization, more and more attention is paid to environmental management, but the implemented standards systems from the ISO 14000 series or similar are not functioning. The growing importance of the implementation of training resulting from the current needs and changes in the organization as well as obligatory training increasing qualifications - training is treated as an element of the strategic and operational plan of the terminal. The manager supports the transfer of knowledge and skills between employees, and also controls and intervenes in the event of failure to achieve the set goals.
	L2 B-	Despite the measurement of the processes, there are no management decisions based on the results obtained. Internal training on raising qualifications is optional.
Level 1 – Measurement of processes	L1 C+	Process measurement is carried out in the area of relationship management in terms of customer satisfaction. The organization conducts training for management staff and conducts training for new employees. Managers of individual departments are involved in solving problems during the process.
	L1 C	Process measurement is carried out in the area of operational, strategic, risk, and security management in terms of the value of revenues generated by the processes. The employee is treated as an independent member of the team that stimulates improvement throughout the organization. The training is integrative, obligatory, and optional and is dedicated to employees of particular departments.
	L1 C-	Process measurement is carried out superficially, mainly in the area of operational and strategic management in terms of time and cost. An additional role of the employee is to initiate improvements in the position held. The training is carried out following the training cycle planned by the company's headquarters, they are treated as an incentive or are not carried out at all.
Level 0 – Identification of processes	L0 D+	Within the organization, processes have been identified and formalized, process measurement is random and distorted. The role of the employee is to perform the tasks entrusted to him.

Source: *Own elaboration.*

To achieve a higher level of process maturity, according to the developed methodology, the minimum criteria for the previous level must be met. To achieve level 1 it is essential to measure the processes connected with safety management, operational, strategic, and risk management. If these conditions are met, then the terminal can be considered as one on the first level of process maturity according to the MMPMMCT. To consider the terminal as one on the second level of process maturity following conditions need to be met: the manager can accelerate the knowledge transfer within the department, and the terminal is providing various internal and external training dedicated to increasing the employees' qualifications.

To qualify the terminal on the highest third level of process maturity rising attention should be made to the environmental issues – in the context of implemented environmental management systems as well as aspects connected with control and measurement of operations on the environment. Moreover, suitable management methods should be implemented, such as elements of lean management, process capability analysis, or the ABC method. The organizational structure can also accelerate the process maturity improvement, especially when the process structure is functioning within the terminal.

3. Results

Three Polish container terminals have been included in the research. All terminals are situated in the Bay of Gdańsk. The names of the container terminal operators are CT1, CT2, and CT3. CT1 has a handling capacity of 1.2 mil TEU, CT2 has a capacity of 3.25 mil TEU, and CT3 has a capacity of 0.63 mil TEU. The questionnaire consisted of 13 questions, and the maximum points that could be achieved were 23.05. The following scale has been introduced to qualify the terminal to adopted level, dimensions, and values are presented in Table 2 indicated the minimum points that had to be achieved to qualify on a particular level and dimension of process maturity.

To qualify the terminal for a higher level it was necessary to meet the criteria for the previous level and long-term development dimension. Besides the lowest level L0, to qualify for a higher level it was essential to achieve at least 4.6 points in the previous level, therefore reaching the level of development in long-term assessment. Only then it was possible to accumulate the sum of points achieved at particular levels.

Table 2. *MMPMMCT scale for level and dimensions of process maturity*

Level and dimension	L0 D+	L1 C-	L1 C	L1 C+	L2 B-	L2 B	L2 B+	L3 A-	L3 A	L3 A+
Accumulated sum of points	0	2.3	4.6	6.9	9.2	11.5	13.8	16.1	18.4	20.7

Source: *Authors' elaboration.*

Results of the conducted research concerning the process maturity level of maritime container terminals are presented in Table 3. Points and present level of maturity are connected concerning the methodology, therefore only if a terminal has met the criteria for the previous level it can be considered as the one with a higher level.

Two of the terminals have met the criteria to achieve level L2 B+ in the adopted methodology, therefore the accumulated sum of points will indicate the final process maturity level of a particular maritime container terminal. One of the examined terminals, namely CT3, achieved level L1 C+ considering the accumulated sum of points. Although this entity has not met all criteria to achieve level L1 C, therefore based on the adopted methodology its process maturity level and dimension is L1 C.

Table 3. *Results of the process maturity level of maritime container terminals*

Terminal	L0 D	L1 C	L2 B	L3 A	Accumulated sum of points	Process maturity level and dimension
CT1	2.05	7.15	6.95	3.9	20.05	L3 A
CT2	2.05	5.1	4.65	6.25	18.05	L3 A
CT3	2.05	3.85	1.35	1.75	9	L1 C-

Source: *Authors' calculations.*

4. Discussion and Conclusions

The research results obtained based on the applied methodology indicate that the level of process maturity of the examined sea container terminals is quite varied. These differences result from various reasons, both objective, arising mainly from the applied models of business process management, being a constituent part of the concepts of operational and strategic management within each terminal, as well as subjective ones. The last ones may stem from the different approaches of the respondents to the questions contained in the survey, which was assumed to be a self-assessment of the applied methods of process management.

Therefore, taking into account both objective and subjective factors when interpreting the reached research results, to objectify them, they should be confronted with performance indicators reflecting the operational efficiency of sea container terminals. They were developed by international organizations such as UNCTAD and World Bank (UNCTAD, 2022; World Bank and S&P Global Market Intelligence, 2022).

UNCTAD developed the liner shipping connectivity index (LSCI). LSCI captures how well countries and container ports are connected to global, predominantly container shipping networks (UNCTAD, 2021). Moreover, in addition to LSCI, UNCTAD computed the liner shipping bilateral connectivity index (LSBCI) for countries' pairs in 2017. LSBCI is calculated from five components as well as LSCI (UNCTADSTAT, 2022).

LSCI providing an indicator of a container port's rank within the liner shipping network can admittedly be partially regarded as a result of the container port's performance. However, it does not directly measure it. In this respect, the container port performance index (CPPI), produced by WB and S&P Global Market Intelligence in 2020, offers much more possibilities. The CPPI is limited only to container ports, making it possible to evaluate the performance of each of them.

In addition, it illustrates the broad approaches identified in the literature on the merits and demerits of each. CPPI as a measure reflects more precisely than LSCI the efficiency of each container port/terminal. It takes into account measures of operational and financial performance, measures of economic efficiency, as well as these that rely, predominately, on data from sources exogenous to the container terminal.

Two different methodological approaches are employed to measure the container terminal performance according to the CPPI formula (World Bank Group and S&P Global Market Intelligence, 2022). The first one, an administrative, or technical approach, based on practical methodology, reflects expert knowledge and judgment. The second, a standard statistical approach, uses factor analysis (FA). The rationale for using both of them was to try and ensure that the ranking of container ports in terms of their performance reflects as closely as possible actual port performance, whilst also being statistically robust.

In the last CPPI 2021 edition, covering 370 container ports all over the world, two Polish container ports, where three container terminals under evaluation are located, were ranked, too. However, one of these ports has one CT 1 terminal, and the other one, has two container terminals, i.e., CT2 and CT3. It means that the ranking results of this port, presented as part of an administrative and statistical approach, take into account the accumulated performance score of both terminals. Its separation is practically impossible.

The positions of the Polish container terminals in the global efficiency ranking, covering a total of 370 terminals, carried out based on the CPPI indicator, broken down into administrative and statistical dimensions, are presented in Table 4.

Table 4. *The rank of Polish container terminals in the world rating based on the CPPI indicator in 2021, taking into account the administrative and statistical dimensions of their performance evaluation.*

Terminals	Administrative approach	Statistical approach
CT1	203	199
CT2 + CT3	255	221

Source: *Authors' compilation on the basis of the World Bank Group publication.*

CT1 was ranked much higher than CT2 and CT3 in each of container terminals' performance areas measured by the CPPI indicator. CT2 position has been significantly reduced in relation to the one obtained by CT1 due to the fact that this terminal was treated together with the terminal CT3, which has a much lower level of process maturity to it.

Thus, the scores obtained in the world ranking by the examined Polish container terminals, fully confirm the results of the research on the level of process maturity of these terminals, carried out by the authors using the adopted methodology. This gives grounds for the conclusion that the developed methodology of measuring the level of process maturity of container terminals may constitute a supplementary dimension of their assessment in relation to the indicators such as LSCI, LSBCI, and especially CPPI developed recently by UNCTAD and the World Bank.

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