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MARITIME CONTAINER SUPPLY CHAIN EFFICIENCY INDICATORS – SELECTED ISSUES FOR RESEARCH AND APPLICATIONS

ABSTRACT

Background: The maritime container supply chains are present in the vast of the global economy. The proper functioning of the supply chain is crucial in the process of creation of the final value. One of the factors of the process is its efficiency. The complexity of nowadays supply chains implies the difficulty of efficiency evaluation. Therefore, the aim of this paper is to develop a set of the efficiency indicators of the maritime container supply chains based on critical literature review and the model of economic efficiency evaluation of the supply chain.

Methods: General research methods are proposed as critical literature review and methods of logical reasoning, and some system construction methods at the form of business process engineering with a reference model of the proposed system of efficiency evaluation of the maritime container supply chain are also applied. This model is constructed with the usage of block scheme method.

Results: Set of efficiency indicators of maritime container supply chains is developed in relation to the forecasting, planning and control modules of the model of efficiency evaluation of the maritime container supply chains.

Conclusions: The proposed reference model of economic efficiency evaluation in maritime container supply chain (MCSC) is an original, value-added conception to solve the problem on measuring the efficiency. The proposed set of indicators of economic efficiency in MCSC is also an original conception, which supports the model with the specification of indicators to be used.

Keywords: supply chains, efficiency evaluation model, efficiency indicators, maritime container supply chain

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INTRODUCTION

The vast of global trade flows through maritime transport [Hoffmann et al. 2018, WTO 2018], and within this branch of transportation, the majority of finished goods are transported by the maritime container vessels [Hoffmann et al. 2018]. Thus the maritime container shipping market (MCSM), which is a major part of the maritime container supply chains (MCSC), as any other markets, has got its own flaws and characteristics [Charlampowicz 2018b, 2018a]. The MCSC, as any other supply chain, are complex structures, more similar to network, than chain [Pryke et al. 2009]. Within the chain form it is possible to identify nodes, where operations are taking place at. These operations can be divided into two main categories: managerial and physical. The efficiency of both categories influences the overall chain efficiency. Due to the importance of MCSC in the global trade it is crucial to identify the efficiency factors of its structure.

Although in the literature there has been devoted a great space for the efficiency and performance issues [Gunasekaran et al. 2004, Banaszewska et al. 2012, Charlampowicz 2017, Mathivathanan et al. 2017], there has been put little focus on economic efficiency of the MCSC. Current state-of-art in the field of maritime container supply chains does not provide a suitable model of indicators for the economic efficiency evaluation system in this area. However, there is an extensive literature connected with the model of performance measurement of supply chains. The most examined and implemented model is the one developed by the Supply Chain Council, i.e. the Supply Chain Operations Reference (SCOR). This model is generally used in identification, measurement, reorganization and improvement of overall supply chains processes [Delipinar and Kocaoglu 2016, Dissanayake and Cross 2018]. This model has been successfully implemented in the manufacturing industry, but SCOR model is not suitable for every business [Lee et al. 2012, Delipinar and Kocaoglu 2016].

The performance of the supply chains can be also measured through utilizing the Balance Scorecard (BSC), which gives an opportunity to evaluate performance from four different perspectives: the financial, the internal business process, the customer, and the learning and growth [Bhagwat and Sharma 2007]. There has been some researches, which concern the performance measurement of supply chains with the usage of BSC (e.g.: [Bhagwat and Sharma 2007, Chia et al. 2009, Bigliardi and Bottani 2010], although none of them focused on the MCSC.

Therefore the aim of this paper is to develop the economic efficiency indicators of the maritime container supply chains, based on the critical literature review and the model of economic efficiency evaluation for the maritime container supply chains. This aim is going to

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be implemented within the following research methodology. First, the research object, i.e. maritime container supply chain efficiency, is characterised with the usage of the literature review as the main research method, based on the logical course of reasoning methods as reduction, induction, and deduction. Second, a reference model of economic efficiency evaluation of the maritime container supply chains is proposed as an answer of the authors' of the article to the literature lack in this subject. This model is constructed with the usage of block scheme method. Third, a set of efficiency indicators of maritime container supply chains is developed in relation to the forecasting, planning and control modules of the above mentioned model. These indicators are presented in the qualitative as well as quantitative form.

This paper is divided as follows:

- Section 1 includes brief characteristics of the MCSM and supply chain efficiency;
- Section 2 is dedicated to efficiency evaluation of the MCSC and presents indicators of economic efficiency evaluation of the MCSC;
- Section 3 provides discussion;
- Section 4 describes research limitations and further research directions;
- Section 5 contains final conclusions.

MARITIME CONTAINER SUPPLY CHAIN EFFICIENCY

Brief characteristics of the maritime container shipping market

According to Review of Maritime Transport, in the 2017 container shipping has expanded for around 6,4 per cent year-to-year, with volumes attaining an estimated 148 million of TEU's [Hoffmann et al. 2018]. This flow of loads was carried by almost 4900 vessels [MDS Transmodal Container Shipping Bulletin November 2017]. Although the number of deployed vessels has dropped yearly and the tonnage on order slightly decreased, due to the fact of placing higher orders for container ships in recent years and introducing mega container vessels, supply side of the market is characterised by an oversupply [MDS Transmodal Container Shipping Bulletin November 2017, Charlampowicz 2018b, Hoffmann et al. 2018].

To reduce cost of the oversupply, the supply side of the market answered with a market concentration, which is expressed in twofold: subjective capital integration and establishment of strategic alliances on the main routes of container transportation. Through M&A, as well as formation of the alliances, the three major alliances controls around 80% of the market [Lee and Song 2017]. Due to these actions the static equilibrium does not exist [Hirata 2017]. Despite the importance and role of the strategic alliances, the MCSM remains globally unconcentrated, however there is a trend of increasing concentration [Charlampowicz 2018a]. The market

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concentration of the supply side, with a respect to membership in the strategic alliance and operated trade route (Atlantic Ocean or Pacific Ocean) presents as follows: Pacific trade lane is still competitive and Atlantic trade route is moderately concentrated [Charlampowicz 2018b].

According to UNCTAD calculations, in 2017 the 752,2 million of TEUs were handled by container ports. The global container throughput has risen by 6 per cent year-to-year [Hoffmann et al. 2018]. More than 64 per cent of the total container throughput were handled by Asian container ports [Hoffmann et al. 2018]. Second busiest region, Europe, accounted for 16 per cent of global container throughput. Development affecting Europeans ports in the 2017 was the growing presence of China Ocean Shipping Company as a principal port investor with facilities in Greece, Italy and Spain. Furthermore the company has established a presence in the Northern Europe by signing concession agreement with Zeebrugge Port Authority to open container port [Hoffmann et al. 2018].

Supply chain efficiency

The concept of efficiency is understood differently by researchers. Some define efficiency the same as performance [Ganga and Carpinetti 2011, Estampe et al. 2013, Shafiee et al. 2014] and some as a one of the components of the performance [Chopra and Meindl 2003, Charlampowicz 2017]. Due to different characteristics and targets of supply chain, [Charlampowicz 2017] proposed three types of efficiency: time-related, cost-related and spatial. It is important to remember that high level of time efficiency, as well as cost and spatial efficiency, is achievable only when supply chain is integrated, which positively influences on information sharing [Koçoğlu et al. 2011].

Time efficiency of the supply chain

Costs in the supply chain plays an important role in the management processes, although the cost reducing actions will not always bring the profitable final outcome. Whenever supply chain is passing through a highly uncertain market, the delivery time and reliability of the one will be more important than minimizing cost. The time efficiency of the supply chain is a feature connected with the agile management, which assumes the ability to meet customer expectations in the context of a lead-time reduction [Agarwal et al. 2007, Gligor et al. 2015, Charlampowicz 2017]. One of the indicators of time efficiency of the maritime container supply chain would be the time required for all needed operations with a container in ports and other transshipment points. The analysis of this information can be helpful in finding bottlenecks in the supply chain,

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and then cooperating with other participants of the supply chain in order to find solutions for decreasing required time [Charlampowicz 2018c].

Cost efficiency of the supply chain

The costs in the supply chain are defined as all significant costs, which are present in the chain [Pettersson and Segerstedt 2013]. Due to the characteristics of supply chain it is crucial to identify all existing costs at every stage of the one. This action can be performed only in the fully integrated supply chain. After identification, costs should be selected based on their importance and amount in order to decide what cost-cutting actions should be taken to achieve cost efficiency. [Gunasekaran et al. 2004] noted that reducing costs at one stage can impact on increasing costs in the other areas.

Spatial efficiency of the supply chain

The geographical location of the centres of individual links and their network partners, plays important role in the process of building competitive advantage of the supply chain [Arnold et al. 2004]. The spatial layout of the network should be determined under the condition that the optimization and rationalization of the total path must be covered between the centers. This aim can be expressed in the total savings generated by the individual participants of the chain, as well as the total savings generated by the whole network. According to above statements, factors such as the reduction of transportation congestion should also be considered [Weisbrod et al. 2016]. Savings generated by the whole network, as well as individual participants, should be maximized with respect to the time and cost. The proper information flow has crucial meaning for chain integration, managing and monitoring the flow of goods through the chain. The ICT tools supporting decision-making processes related to the transportation have got a direct impact on the efficiency of processes in the supply chains [Kolinski and Jaskolska 2018].

The spatial efficiency is expressed in mutual relation between cost and time. To maximize this type of efficiency, during the planning of network, factors such as a physical location of the individual links and partners, states and characteristics of the infrastructure links the individual centers, and local regulations should be above all taken into account [Charlampowicz 2017].

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EFFICIENCY EVALUATION OF THE MARITIME CONTAINER SUPPLY CHAIN

Reference model of the economic efficiency evaluation of the maritime container supply chain

In the literature there is a gap of knowledge concerning the problem of economic efficiency evaluation of the MCSC. Some authors examined the efficiency issues connected with the maritime container terminal, which is a crucial part of the MCSC. Most researchers are focused into the technical efficiency of the maritime container terminal [Cullinane et al. 2002, Jiang and Li 2009, Almawsheki and Shah 2015, Pérez et al. 2016, Kutin et al. 2017], which is one of the parts of overall economic efficiency. Some papers has been devoted to the relation between different types of efficiencies at the terminals level [Kaselimi et al. 2011, Bichou 2013]. Some authors examined the performance of supply chain by using SCOR model [Lee et al. 2012, Delipinar and Kocaoglu 2016, Dissanayake and Cross 2018] and others utilise the BSC to evaluate the supply chain [Park et al. 2005, Bhagwat and Sharma 2007, Chia et al. 2009, Bigliardi and Bottani 2010], although there is no space devoted to the efficiency of the MCSC.

Based on the above critique, the reference model is presented in the Fig.1, as the author of the article original proposition to perceive the economic efficiency evaluation of the MCSC.

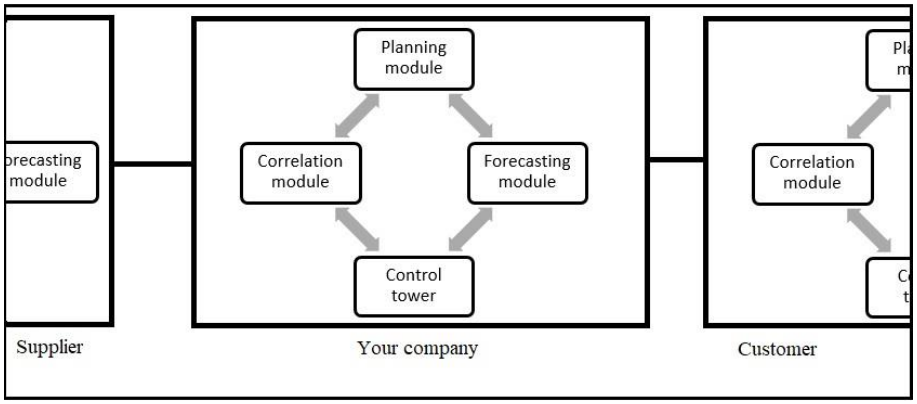

Figure 1. Reference model of the economic efficiency evaluation of the MCSC
Source: own elaboration

The presented model consists of four mutually related modules: planning module, forecasting module, correlation module and control tower. Each of the modules contains several sub-modules, which are presented at the Fig. 2.

The planning module should integrate various information on the strategical, tactical and operational level. Information and data regarding numerous subjects are crucial for proper functioning and the performance of right and profitable actions. Decisions can be divided into

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three categories: economic, technical and technological, and operational. Every category has corresponding submodule, which should contain suitable efficiency indicators, with respect to time, as well as costs. The decision and targets made in the planning module should be established with regard to the time horizon at the strategical, tactical and operational level.

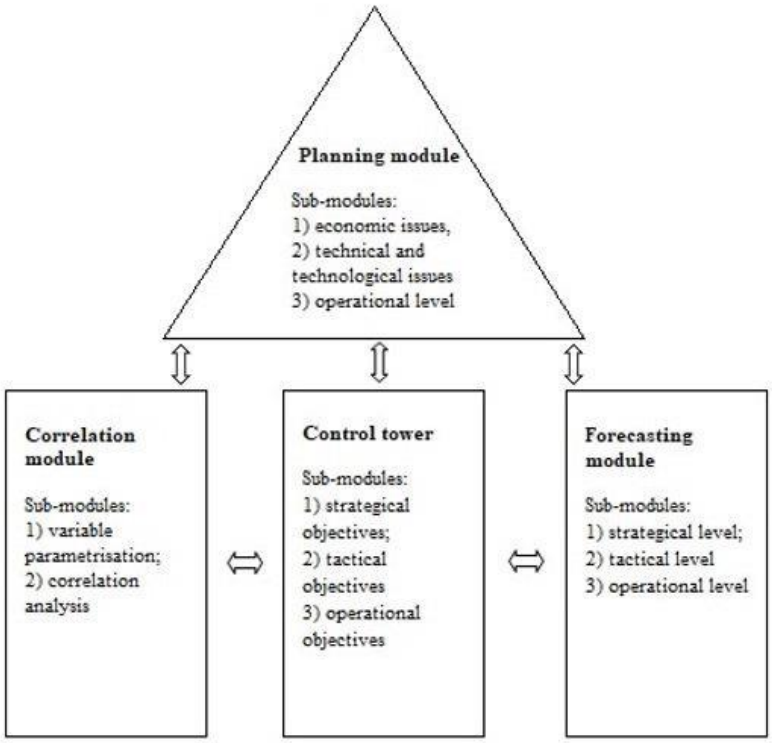

Figure 2. Sub-modules of the system of economic efficiency evaluation of the maritime container supply chain
Source: own elaboration

Second module is the control tower, which is divided into three categories, which correspond with the control activities over plan fulfilment and correctness of actions at strategical, tactical and operational level. Every submodules, identified in the control tower, should provide constant supervision of company's actions with reference to set targets at various levels. Every major differences between plan and reality should be examined for its source and the impact on the established targets. Due to its characteristics the operational level is the only one, which can change almost every day. Major changes at the operational level can influence the ability, or lack of ability, to achieve targets at tactical and strategical level. Reports and related actions should be taken immediately after operational objectives' modifications and as fast as the variation between plans and results occurs.

Another identified module in the reference model of the economic efficiency evaluation in the MCSC is the forecasting one. This module is divided into three categories based on the range of the forecast. Therefore there is also strategical level, tactical level and operational

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level. Forecasts should be made with reference to planning module' submodules: economic issues, technical and technological issues, and operational issues. Additionally, it is crucial, during forecast, to analyse the correctness of plan fulfilment based on control tower.

Last identified module is a correlation one, which includes two submodules: variable parametrisation and correlation analysis. In every modules, it is possible to develop some efficiency indicators but it is important to find out the relation between metrics from other modules. Some indicators are strongly correlated with others, and it is important to examine the impact of it on another one. For instance, high prices of new ICT system, which increase integration within the supply chain, can influence a lower ability to invest in this asset, which in turn can influence a decrease of ability to acquire information, which can influence a lower ability to being resilient, weaker competitive power and lower income. The correlation module performs also a role of an integrator of the other modules in the presented model.

Efficiency indicators of the MCSC

Set of efficiency indicators of the MCSC is presented at the Fig. 3. Indicators have been developed with a reference to the proposed modules and sub-modules (Fig. 2).

Indicators of efficiency in the planning module

The planning module consists three submodules: economic issues, technical and technological issues and operational issues. In every submodule there is possibility to create indicators for economic efficiency evaluation for MCSC. It is required to remember that every developed indicator should be confronted with the business reality.

In the economic issues submodule first indicator is a demand fulfilment. This indicator can be defined as a relation between demand and the ability to fulfil it with respect to time of operations that need to be taken. In the category of economic issues the cost efficiency of an operation should also be taken under consideration, therefore another efficiency indicator should be the total cost of link, or chain, and the relation between this value and the container throughput. It is also possible to connect the above mentioned efficiency indicator with profit, although the container throughput tells more about actual demand and fulfilment of this demand.

In the technical and technological issues submodule, one of the efficiency indicators, based on presented above model, is the technical efficiency of equipment related to the degree of usage, which can be defined as a relation between technical efficiency of the equipment and the utilization of it. This indicator gives a clear view when equipment should be renewed. It has to

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be remembered that, because of mathematical correctness, the value of equipment utilization should not be equal to 0.

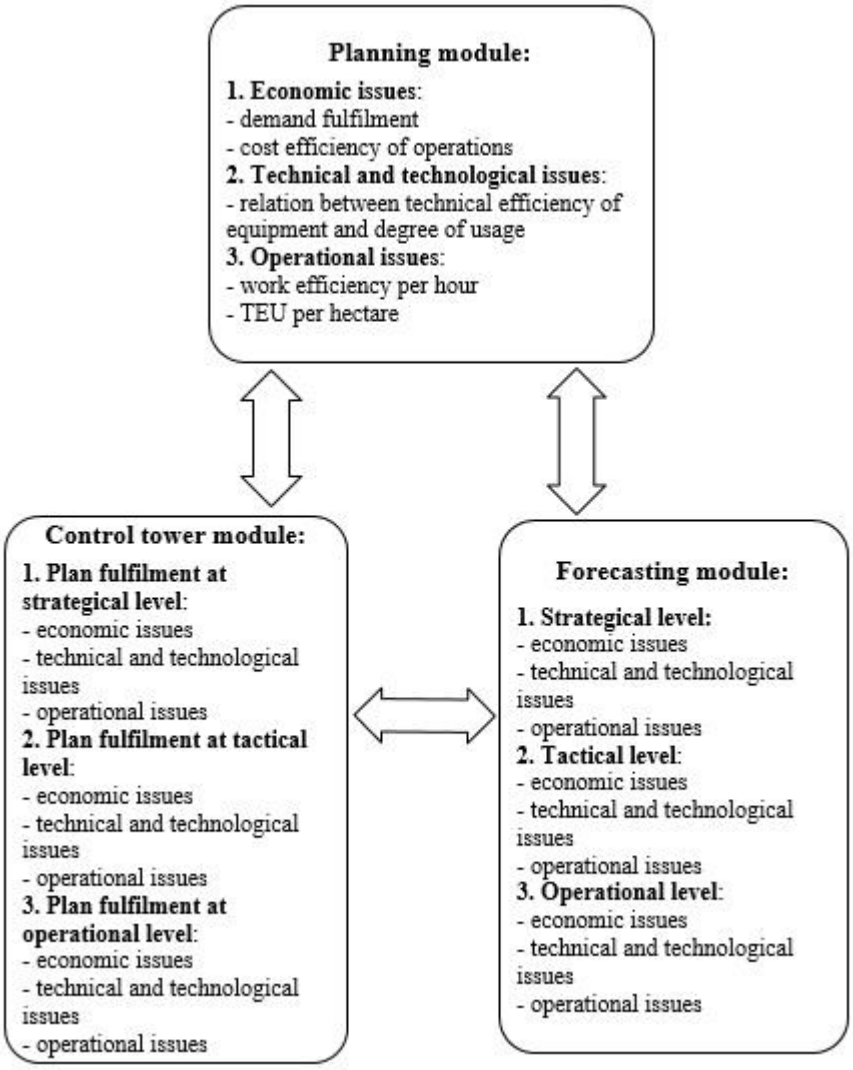

Figure 3. Set of efficiency indicators of the MCSC

Source: own elaboration

Efficiency indicators for operational issues are connected with the organization of work. In this field it can be identified: physical work organization and managerial/administrative work organization. In the field of physical work organization it is possible to adopt and develop some efficiency indicators such as: e.g. work efficiency per hour, in which the efficiency of employees is calculated by relation between operated TEU in one hour. Of course it is also possible to adopt other efficiency indicators, introduced in the literature and business practice such as TEU per hectare etc. [Hoffmann et al. 2018].

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Indicators of efficiency in the control-tower module

The control tower module is dedicated to the controlling over correctness of plan fulfilment at different levels (strategical, tactical and operational). Each of the submodules should provide efficiency indicators connected with planning module. Typical efficiency indicator, which can be adopted to this model, would be the plan fulfilment. This indicator should contain data from planning module concerning the plan at examined stage (strategical, tactical, operational) in the particular part such as economic issues and information concerning actual value in this part. If the relation between cost and container throughput is higher than planned, then the source of this disruption has to be found (e.g. the lower demand is the source, because of rising competition etc.) Every major difference between plan and actual values needs to be reported and the solution for it is required to be found. Similar situation occurs with the other submodules of planning module and with other ranges of actions as tactical or operational levels.

The control over achieving plans at the operational level is continuous type of action, in which it is also essential being conscious about the tactical and strategical objectives and the fact, how changes at the operational level have got an impact on the ability or possibility of achieving the targets.

Indicators of efficiency in the forecasting module

The forecast should be made based on planning and control-tower modules, which give clear view about the plan fulfilment, reasons of disruptions and previous forecast. Efficiency indicators for forecasting module should be also divided into three categories with regard to range of forecast, so there should be indicators for strategical, tactical and operational level.

Efficiency indicators in the strategical submodule, similarly to other submodules of forecasting module, should measure the relation between the previous forecasts, which are directly connected with plan, and the actual results. This metric can provide decision-makers with information about the correctness of forecasts. Moreover efficiency indicators should be related to the specific planning module' submodules, such as economic issues, technological and technical issues, and operational issues.

DISCUSSION

The above presented indicators for economic efficiency evaluation of MCSC are dedicated to the proposed reference model. This model gives the advantage of generalisation and broader application possibilities. Division of indicators into three categories gives an opportunity to develop, implement and measure efficiency at the different stages of supply chain. The main

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reason of efficiency indicators' absence in the correlation module is the fact that the module is focused on the relation between indicators of efficiency in other modules.

The disadvantages of presented indicators can be perceived at the requirements of adjusting metrics to specific elements of maritime container supply chain, because of their characteristics and importance. During designing and developing the indicators, their applicability at a global level should be taken under consideration. This is the main reason why presented indicators have general dimension.

RESEARCH LIMITATIONS AND FURTHER RESEARCH DIRECTIONS

Research limitations

The lack of possibility to acquire data regarding specific link or chain strategy, including plan, objectives and plan achievement at strategical, tactical and operational level, greatly limited the possibility of confronting the presented model and metrics with the economic reality. This lack of ability to implement indicators also restrained the author's intention to conduct more extensive research and the development of more suitable efficiency indicators.

Further research directions

The presented set of indicators for economic efficiency evaluation of the MCSC should be confronted with the economic and business reality expressed in the form of implementation of the proposed model and metrics to operations of MCSC. This action would be very useful in terms of managerial, as well as, scientific point of view. Another research direction of great importance is to develop, design and adjust the efficiency indicators and confront them with business processes at local (link) and global (whole network) level.

The presented set of indicators provides results in various units, which can lead to complications with the evaluation of the results at the particular module level. The further research direction of great value, based on empirical findings, is fitting the model to business reality and solving the problem of various measuring units.

CONCLUSIONS

In the literature little space has been devoted to the efficiency issues in the MCSC as a whole. Mostly, researchers focused on one particular link, which is the maritime container terminal. This choice was made due to the characteristics and homogeneity of operations taking place at this link. In addition, authors are mostly focused on the one type of the efficiency, which is the technical one. Only few authors has examined other types of efficiencies and the relation

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between them, but also only at the terminal level. On the other hand, there is extensive literature concerning overall performance of supply chain using SCOR model and BSC but no MCSC has been examined yet.

The aim of this paper, based on the literature review, was an attempt to design and develop indicators of economic efficiency of MCSC based on reference model of the economic efficiency evaluation system for MCSC. The brief characteristics of the MCSM, which are the relevant part of the MCSC, have been presented. The efficiency issues concerning supply chains with respect to time, cost and space have been discussed. Moreover the economic efficiency indicators for MCSC with relation to planning, forecasting and control modules in the presented model, were proposed.

This paper is the first attempt to develop and design economic efficiency indicators for MCSC based on original reference model of the economic efficiency evaluation system for MCSC. Based on the research findings the main conclusions are:

- The proposed reference model of economic efficiency evaluation in MCSC is an original, value-added conception to solve the problem on measuring the efficiency;
- The proposed set of indicators of economic efficiency in MCSC is also an original conception, which supports the model with the specification of indicator to be used.

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REFERENCES

Agarwal A., Shankar R., Tiwari M. K., 2007, Modeling agility of supply chain, Industrial Marketing Management, 36(4), pp. 443–457. DOI: 10.1016/j.indmarman.2005.12.004.

Almawsheki E. S., Shah M. Z., 2015, Technical Efficiency Analysis of Container Terminals in the Middle Eastern Region, Asian Journal of Shipping and Logistics. Elsevier B.V., 31(4), pp. 477–486. DOI: 10.1016/j.ajsl.2016.01.006.

Arnold P., Peeters D., Thomas I., 2004, Modelling a rail/road intermodal transportation system, Transportation Research Part E: Logistics and Transportation Review, 40, pp. 255–270. DOI: 10.1016/j.tre.2003.08.005.

Banaszewska, A. et al., 2012, A framework for measuring efficiency levels - The case of express depots, International Journal of Production Economics. Elsevier, 139(2), pp. 484–495. DOI: 10.1016/j.ijpe.2012.05.003.

Bhagwat R., Sharma M. K., 2007, Performance measurement of supply chain management :

A balanced scorecard approach, Computers & Industrial Engineering, 53, pp. 43–62. DOI: 10.1016/j.cie.2007.04.001.

Bichou K., 2013, An empirical study of the impacts of operating and market conditions on container-port efficiency and benchmarking, Research in Transportation Economics. Elsevier Ltd, 42(1), pp. 28–37. DOI: 10.1016/j.retrec.2012.11.009.

Bigliardi B, Bottani E., 2010, Performance measurement in the food supply chain : a balanced scorecard approach, Facilities, 28(5/6), pp. 249–260. DOI: 10.1108/02632771011031493.

Charlampowicz J., 2017, Measurement of Supply Chain Efficiency- Selected Issue for Research and Applications, 17th International Scientific Conference Business Logistics in Modern Management, pp. 471–483.

Charlampowicz J., 2018a, Analysis of the market concentration of the Maritime Container Shipping Markets – selected issues, SHS Web of Conferences, 58, p. 01005. DOI: https://doi.org/10.1051/shsconf/20185801005.

Charlampowicz J., 2018b, Market concentration of strategic alliances members in the maritime container shipping market on trade lanes passing across the Atlantic and the Pacific - selected issues, in Proceedings of the 4th International Conference on Traffic and Transport Engineering. Belgrade, pp. 373–377.

Charlampowicz J., 2018c, Supply chain efficiency on the maritime container shipping markets - selected issues, 18th International Scientific Conference Business Logistics in Modern Management, pp. 357–369.

Chia A., Goh M., Hum S. H., 2009, Performance measurement in supply chain entities: balanced scorecard perspective, Benchmarking: An International Journal, 16(5), pp. 605–620. DOI: https://doi.org/10.1108/14635770910987832.

Chopra S., Meindl P., 2003, Supply chain management: strategy, planning, and operation - third edition. DOI: 10.1007/s13398-014-0173-7.2.

Cullinane K., Song D. W., Gray R., 2002, A stochastic frontier model of the efficiency of major container terminals in Asia: Assessing the influence of administrative and ownership structures, Transportation Research Part A: Policy and Practice, 36(8), pp. 743–762. DOI: 10.1016/S0965-8564(01)00035-0.

Delipinar G. E., Kocaoglu B., 2016, Using SCOR Model to Gain Competitive Advantage: A Literature Review, Procedia - Social and Behavioral Sciences. The Author(s), 229, pp. 398–406. DOI: 10.1016/j.sbspro.2016.07.150.

Dissanayake C. K., Cross J. A., 2018, Systematic mechanism for identifying the relative impact of supply chain performance areas on the overall supply chain performance using SCOR

model and SEM, International Journal of Production Economics. Elsevier Ltd, 201(October 2017), pp. 102–115. doi: 10.1016/j.ijpe.2018.04.027.

Estampe D. et al., 2013, A framework for analysing supply chain performance evaluation models, International Journal of Production Economics. Elsevier, 142(2), pp. 247–258. DOI: 10.1016/j.ijpe.2010.11.024.

Ganga G. M. D., Carpinetti L. C. R., 2011 A fuzzy logic approach to supply chain performance management, International Journal of Production Economics, 134(1), pp. 177–187. DOI: 10.1016/j.ijpe.2011.06.011.

Gligor D. M., Esmark C. L., Holcomb M. C., 2015 Performance outcomes of supply chain agility: When should you be agile?, Journal of Operations Management. Elsevier B.V., 33–34, pp. 71–82. DOI: 10.1016/j.jom.2014.10.008.

Gunasekaran A., Patel C., McGaughey R. E., 2004, A framework for supply chain performance measurement, International Journal of Production Economics, 87(3), pp. 333–347. DOI: 10.1016/j.ijpe.2003.08.003.

Hirata E., 2017, Contestability of Container Liner Shipping Market in Alliance Era, Asian Journal of Shipping and Logistics. Elsevier B.V., 33(1), pp. 27–32. DOI: 10.1016/j.ajsl. 2017.03.004.

Hoffmann J. et al., 2018, UNCTAD Review of Maritime Transport 2018. Available at: http://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf.

Jiang B., Li J., 2009, DEA-based performance measurement of seaports in northeast Asia: Radial and non-radial approach, Asian Journal of Shipping and Logistics. The Korean Association of Shipping and Logistics, Inc., 25(2), pp. 219–236. DOI: 10.1016/S2092-5212(09)80003-5.

Kaselimi E. N. et al., 2011, Minimum Efficient Scale (MES) and preferred scale of container terminals, Research in Transportation Economics. Elsevier Ltd, 32(1), pp. 71–80. DOI: 10.1016/j.retrec.2011.06.006.

Koçoğlu I. et al., 2011, The effect of supply chain integration on information sharing: Enhancing the supply chain performance, Procedia - Social and Behavioral Sciences, 24, pp. 1630–1649. DOI: 10.1016/j.sbspro.2011.09.016.

Kutin N., Nguyen T. T., Vallée T., 2017, Relative Efficiencies of ASEAN Container Ports based on Data Envelopment Analysis, Asian Journal of Shipping and Logistics, 33(2), pp. 67–77. DOI: 10.1016/j.ajsl.2017.06.004.

Lee C. Y., Song, D. P., 2017, Ocean container transport in global supply chains: Overview and research opportunities, Transportation Research Part B: Methodological. Elsevier Ltd, 95,

pp. 442–474. DOI: 10.1016/j.trb.2016.05.001.

Lee K. H. et al., 2012, The applications of SCOR in manufacturing: Two cases in Taiwan, Procedia Engineering, 38, pp. 2548–2563. DOI: 10.1016/j.proeng.2012.06.300.

Mathivathanan D., Govindan K., Haq, A. N., 2017, Exploring the impact of dynamic capabilities on sustainable supply chain firm's performance using Grey-Analytical Hierarchy Process, Journal of Cleaner Production. Elsevier Ltd, 147, pp. 637–653. DOI: 10.1016/j.jclepro.2017.01.018.

MDS Transmodal Container Shipping Bulletin November 2017 (2017).

Park J. H., Lee J. K., Yoo J. S., 2005, A framework for designing the balanced supply chain scorecard, European Journal of Information Systems, 14(June), pp. 335–346. DOI: 10.1057/palgrave.ejis.3000544.

Pérez I., Trujillo L., González M. M., 2016, Efficiency determinants of container terminals in Latin American and the Caribbean, Utilities Policy, 41, pp. 1–14. DOI: 10.1016/j.jup. 2015.12.001.

Pettersson A. I., Segerstedt A., 2013, Measuring supply chain cost, International Journal of Production Economics. Elsevier, 143(2), pp. 357–363. DOI: 10.1016/j.ijpe.2012.03.012.

Pryke S. et al., 2009, Construction Supply Chain Management: Concepts and Case Studies. Edited by S. Pryke. Wiley-Blackwell Publishing Ltd. DOI: http://dx.doi.org/10.1002/ 9781444320916.

Shafiee M., Hosseinzadeh Lotfi F., Saleh H., 2014, Supply chain performance evaluation with data envelopment analysis and balanced scorecard approach, Applied Mathematical Modelling. Elsevier Inc., 38(21–22), pp. 5092–5112. DOI: 10.1016/j.apm.2014.03.023.

Weisbrod G., Mulley C., Hensher D., 2016, Recognising the complementary contributions of cost benefit analysis and economic impact analysis to an understanding of the worth of public transport investment: A case study of bus rapid transit in Sydney, Australia, Research in Transportation Economics. Elsevier Ltd, 59, pp. 450–461. DOI: 10.1016/ j.retrec.2016.06.007.

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