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## A MODEL OF AN ECONOMIC EFFICIENCY EVALUATION SYSTEM OF A MARITIME CONTAINER SUPPLY CHAIN

### Abstract

Containerization was one of the catalysts of the globalization processes that took place in the 20<sup>th</sup> century. Nowadays container shipping is one of the main transport modes in the global economy. The ability to connect distant production centres with consumption centres largely influenced the acceleration of the global trade. Due to the globalization and characteristics of the global trade it is almost impossible to perceive global supply chains without maritime transport. Although the efficiency of the supply chain is a crucial factor of the economic perspective of supply chain management, not much space is devoted to that issue in the literature. The main purpose of this paper is to design and develop a model of an economic efficiency evaluation system of maritime container supply chains. Some general research methods, such as a critical literature review and methods of logical reasoning were used to achieve this goal. Additionally some economic modelling methods were adapted. The presented model is developing the current state-of-the-art knowledge in the field of economic efficiency evaluation of supply chains. Unfortunately this model could not be confronted with real business data due to research limitations.

**Keywords:** economic efficiency evaluation system, supply chain efficiency, reference model, supply chain management

**JEL:** B27, R40

### Introduction

One of the features of the modern trade is globalization which is expressed in the possibility to connect distant production centres with consumption places through a set of complex processes and operations. Such operations are performed

within supply chains, which are complex structures in respect of which, due to many links on various levels, a more applicable term would be a supply network (Pryke, 2009). Within these networks the maritime transport plays an important role, as an integrator of different transport nodes. The average increase in sea freight during the period 2005–2016, in million loaded tones, was 5.2%. In 2016 the global containerized trade expanded by 3.2% year-to-year, with volumes attaining an estimated 140 million TEUs per annum (Hoffmann et al., 2017). General cargo accounts for around 60% of the global shipped goods by value, most of which is transported by containerized liner services (Stopford, 2009).

Although much space in the literature has been devoted to efficiency and performance issues (e.g., Gunasekaran et al., 2004; Banaszewska et al., 2012; Brandenburg, 2016; Charłampowicz, 2017, 2018; Mathivathanan et al., 2017) there has been no focus on issues of the economic efficiency of maritime container supply chains (Charłampowicz, 2017, 2018). The current state-of-the-art knowledge in the field of maritime container supply chains does not propose any proper model of economic efficiency evaluation of maritime container supply chains. The purpose of this paper is to develop and design a model of an economic efficiency evaluation system for maritime container supply chains. The above stated purpose is carried out through a research process which covers general research methods, such as: a critical literature review and methods of logical reasoning as well as methods oriented on modelling and simulation of economic systems, including a reference model of the system proposed in this article.

Some research limitations were encountered when conducting the research. A main research limitation was the lack of a possibility to confront the proposed model with real business data expressed in global supply chains.

The paper is divided as follows: section 1 provides a literature review concerning the supply chain efficiency, section 2 presents a model of economic efficiency evaluation of a maritime container supply chain, section 3 provides discussion and finally section 4 includes final conclusions.

## **1. Literature review concerning supply chain efficiency**

Supply chain management is a set of processes and actions the main target of which is to coordinate processes and relationships occurring inside and outside a supply chain with the aim of maximizing the surplus for the final customer. These actions are carried out through the implementation of a proper supply chain management strategy. The main strategies of supply chain management are: lean, agile, leagile, resilient, green and sustainable (Stratton, Warburton, 2003; Kisperska-Moron, de Haan, 2011; Carvalho et al., 2012; Nieuwenhuis, Katsifou, 2015; Kamalahmadi, Parast, 2016; Tseng et al., 2019). Those strategies have different targets, hence, the implementation of a strategy to a supply chain depends on the market environment and the supply chain characteristics. Based on the implemented strategy the output of the system will be different. It can be said that the main target of every strategy is to maximize the final efficiency of the supply chain in different

contexts. It can be said that, e.g., the main target of a lean supply chain would be maximizing the cost efficiency.

The literature of the subject fails to distinguish between the concept and indicators of efficiency and performance which are understood in the same way (Ganga, Carpinetti, 2011; Estampe et al., 2013; Shafiee et al., 2014). On the other hand, there are researchers, who conceptualize efficiency as one of the factors influencing the overall performance and perceive efficiency from the economic point of view, which is connected with the cost of manufacturing and delivering goods to the final customer (Chopra, Meindl, 2003; Roh et al., 2014). Azfar et al. (2014) proposed a conceptual framework for measuring the performance of a supply chain managed with regard to the LARG practices which are a combination of lean, agile, resilient and green methods. This framework was divided into operational performance, economic performance and environmental performance. The factors included in the category of the economic performance are in fact connected with the economic efficiency of a supply chain.

In the literature there is a gap in the knowledge concerning the efficiency of supply chains in the context of designing and developing a proper model of efficiency evaluation. However, the literature connected with a model of performance measurement of a supply chain is extensive. The most frequently examined and implemented model is the one developed by the Supply Chain Council, which is the Supply Chain Operations Reference (SCOR). This model is generally used in identification, measurement, reorganization and improvement of overall supply chain processes (Delipinar, Kocaoglu, 2016; Dissanayake, Cross, 2018). These processes, namely plan, source, make, deliver and return, are presented in Figure 1.



Figure 1. SCOR model

Source: (own elaboration based on: Delipinar, Kocaoglu, 2016)

The SCOR model provides a methodology for managing SC activities and processes. “Plan” refers to analyzing information and forecasting market trends, “Source” is connected with the procurement system, “Make” refers to the manufacturing of goods, “Deliver” involves activities of provision of goods or services and “Return” refers to returning goods or receiving a product (Trkman et al., 2010). This model has 4 SC management levels. Level 1 provides an extensive definition of basic processes and helps entities form the supply chain management objectives.

Level 2 defines the core processes that are possible components in the supply chain. Level 3 provides the company with information needed to set goals successfully for SC improvements. Level 4 is connected with implementation. Since supply chains operate in different market environments and supply chain management improvements are unique for each company the SCOR model does not provide any specific parts of this level (Stewart, 1997; Delipinar, Kocaoglu, 2016; Dissanayake, Cross, 2018).

The SCOR model has been widely and successfully implemented in the manufacturing business. Lee et al. (2012) examined the effects of the SCOR model implementation in a Taiwanese manufacture industry. The results indicate that the SCOR model can be widely and successfully used in other companies. Based on an extensive literature review concerning the SCOR model (Delipinar, Kocaoglu, 2016), in the context of gaining a competitive advantage, it can be said that the SCOR model is not applicable in every industry. As shown in the research, the SCOR model is suitable for the manufacturing industry, however, it is not easy to apply in the construction industry (Delipinar, Kocaoglu, 2016). A similar situation can exist in other industries, where the SCOR model possibly does not fit. It is crucial to remember that the SCOR model provides a measurement system for the overall performance of a supply chain, and in the literature there is no space devoted to the measurement system for the efficiency of maritime container supply chains.

The maritime container supply chains which are a part of the maritime container shipping markets have volatile characteristics and must have abilities to rapidly react in a changing market environment. Those features are present due to the high market concentration on the maritime container shipping market (Hirata, 2017).

The main purpose of this paper is to make an attempt to design and develop a suitable economic efficiency evaluation system for maritime container supply chains. When conducting the research on the economic efficiency evaluation of maritime container supply chains it is crucial to remember that economic efficiency is a derivative of other types of efficiency, such as technical, managerial and technological, and this overall efficiency is one of the components of the supply chain performance. The literature in the field of supply chain efficiency does not provide a suitable solution for the evaluation of maritime container supply chains efficiency with reference to the above mentioned types of efficiency. Some general research methods were applied to conduct this study properly. First, a literature review concerning the supply chain efficiency was conducted and a model of supply chain performance measurement was performed. Based on this review the gaps in the knowledge were identified. Secondly, the research was conducted based on economic modelling and simulation methods including a reference model of the proposed system.

## 2. Reference model of economic efficiency evaluation of maritime container supply chains

The literature study performed earlier in the article proves that there is a gap of knowledge concerning the economic efficiency evaluation of maritime container supply chains. Therefore, the reference model of a system of economic efficiency evaluation of the maritime container shipping market is proposed in Figure 2.

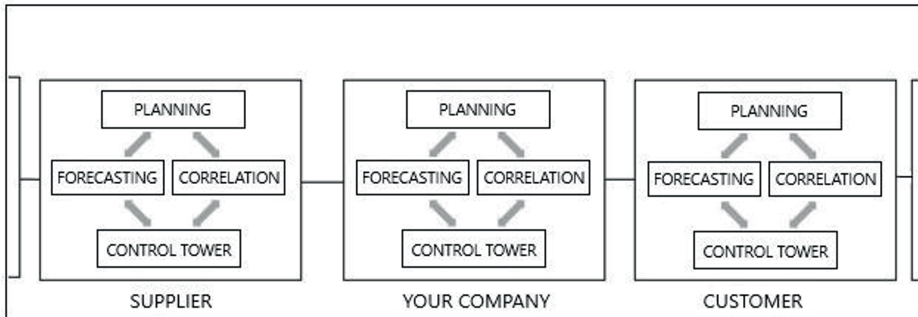


Figure 2. Model of the structure of a system of economic efficiency evaluation of a maritime container supply chain

Source: (own elaboration)

The model of the structure of a system of economic efficiency evaluation of a maritime container supply chain consists of four interrelated modules:

- planning module;
- control module;
- correlation module;
- forecasting module.

Each of the modules has several sub-modules which are presented in Figure 3.

The planning module should integrate various information on strategic, tactical and operational levels. The information and data regarding numerous subjects are crucial for managerial and operational activities. The first sub-module is connected with economic issues which can be distinguished as demand, customer needs, competitiveness and human resources management. The above mentioned information can be used in developing a plan concerning economical and financial data. The sub-module on technical and technological issues should contain such information as: the cost of repairs and maintenances, the degree of equipment utilization, prices of new and used equipment, the cost of ICT systems and the cost of integration within the chain. The last identified sub-module is the operational level which can be divided into two categories: work organization of physical employees and work organization of administrative and managerial staff. The work organization should contain information regarding specific tasks and division of labour.

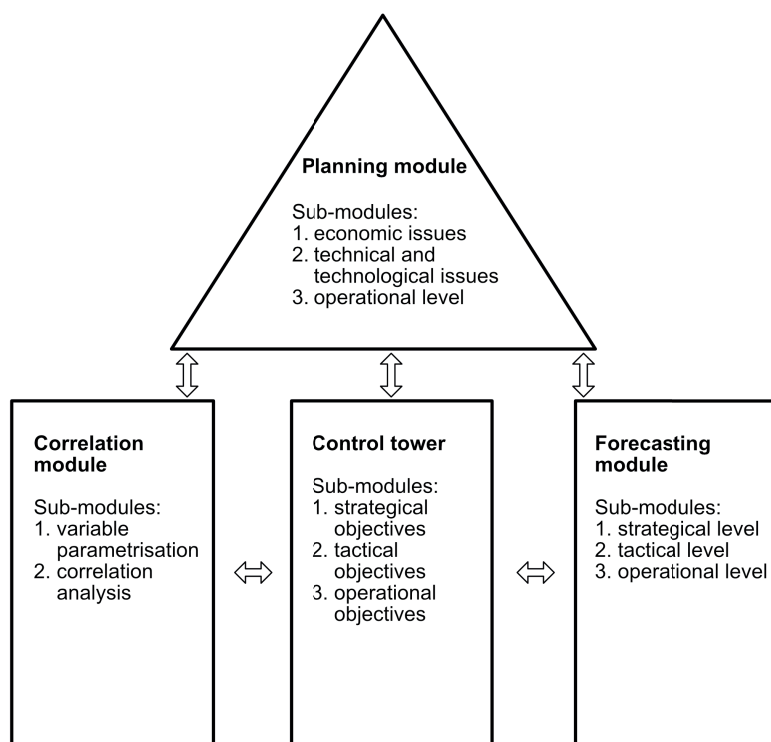


Figure 3. Sub-modules of the system of economic efficiency evaluation of a maritime container supply chain  
Source: (own elaboration)

Another identified module in the economic efficiency evaluation system of maritime container supply chains is the correlation module. This component includes two sub-modules: variable parameterization and correlation analysis. In each sub-module it is possible to create and develop suitable indicators of economic efficiency, e.g. the condition and availability of a superstructure. It is crucial to remember that some of those indicators are strongly correlated with each other, and it is important to examine the impact of the change of one indicator on another (e.g. high prices of a new ICT system, which increase the integration within the supply chain can have influence on a lower ability to invest in this asset which can have influence on a decrease in the ability to acquire information, which can have influence on a lower ability to be resilient, weaker competitive power and lower income). The relation between specific indicators should be found with regard to strategic and tactical plans.

The third module is a control tower which is also divided into three categories, which are responsible for the correctness and control over the implementations of plans at the strategic, tactical and operational levels. The sub-module of the strategical objectives should provide constant supervision over the company's actions with reference to the set strategic targets. This verification should be made based

on the key performance indicators and their relations to the planning module. Every major change and difference between the plan and reality should be examined for its source and correctness with the plan. The second sub-module of the control tower is connected with control over achieving the tactical objectives. This component is connected with the verification of achieving, and the ability to achieve the targets at the tactical as well as strategic levels. To accomplish this goal it is crucial to develop and examine the correlation between indicators at strategic and tactical levels with reference to the plan. Every major change and difference between the plan and reality should be reported and revised. The last sub-module in the control tower is dedicated to the control over achievement of operational objectives. Even though it is important to set operational objectives with reference to the tactical and strategic goals and plans, this sub-module is the only one which can be adjusted almost every day. Major changes at the operational level can influence the ability, or lack of the ability, to achieve targets at the tactical and strategic levels. Reports and related actions should be taken immediately after modifications of operational objectives and as fast as the variation between plans and results occurs.

The last identified module is a forecasting module which is also divided into three categories connected with the range of the forecast. These categories are: strategic, tactical and operational level forecasts. It is important to remember that the forecast at every level should consist of three sections: economic issues, technical and technological issues and operational issues. This systematization gives a clear view that the forecasting should be made based on the sub-modules of the planning module. Although during the forecast it is crucial to take into account the control tower module which verifies the fulfilment of the earlier plan and correctness of the forecasts that have been made.

As it is shown in Figure 2, the above presented model of economic efficiency evaluation for maritime container supply chains should be implemented at every stage of the supply chain. The information flow concerning specific data from every module, with a high level of the supply chain integration, gives an opportunity to correlate forecasts and plans to create a higher value for the final customer.

### **3. Discussion**

The above presented model is a reference model, what gives the advantage of generalization. Although this model has been designed and developed specifically for maritime container supply chains, however, due to its general nature, it can be implemented to any supply chain. On the other hand, the main disadvantage of this model can be perceived as the requirements for developing suitable indicators and metrics in every process, which can be challenging from application point of view. Therefore, the development of indicators should be made with reference to the specific maritime container supply chain characteristics, which can also differ from each other, although it should be applicable at the global level, as well. Another important issue is connected with the specific number and exact indicators in every sub-module. The proposed set of measures can differ in relation to the characteristics of specific links in the supply chain, and the supply

chain as a whole. An additional problem is dedicated to the weight of particular sub-modules and the weight of the indicators of the sub-modules. This weight can differ in relation to the characteristics of the partner in the supply chain, e.g. special attention should be paid to the economic issues, and to the technical and technological issues.

## Conclusions

A gap in the knowledge concerning economic efficiency evaluation for maritime container supply chains was identified based on the literature review. Most papers focused on the performance issues using the SCOR model (Lepori et al., 2013; Dissanayake, Cross, 2018), which is not always applicable for all industries (Dissanayake, Cross, 2018). During the literature research, it was noticed that the SCOR model had not been implemented in the maritime container supply chain and there was no space devoted to the economic efficiency evaluation of the maritime container supply chain. This paper made an attempt to fill this gap by developing an original method of economic efficiency evaluation of the maritime container supply chain.

The above presented model should be confronted with the economic reality expressed in the form of implementation of this model to the maritime container supply chain. The results of this action would be very interesting from the managerial as well as scientific points of view. Another research direction of great importance is the further development of this model in the three categories:

- development of specific indicators for every sub-module;
- verification of indicators with the real business data;
- setting weights to specific sub-modules.

The lack of a possibility of acquiring empirical data concerning the maritime container supply chain strategy and plan achievement at the strategic, tactical and operational levels at every stage of the supply chain, greatly limited the ability of the conducted research. Therefore, based on the research findings, the main conclusions can be stated as follows:

1. The proposed model gives an opportunity to assess the economic efficiency of maritime container supply chains in a more reliable and accurate way than another solution.
2. Empirical verification of the proposed model is needed with respect to the business environment, and specific indicators and metrics should be developed for every sub-module based on its design.

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