

Determinants of liner shipping connectivity

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ARTICLE INFO

Article history:

Received 16 May 2019

Received in revised form

20 August 2019

Accepted 21 August 2019

Keywords:

Liner shipping connectivity

Logistics performance

Container transit times

Container transport costs

Seaport

ABSTRACT

The study of shipping connectivity has taken more attention from researchers in recent years. This paper analyzes the determinants of liner shipping connectivity for a sample of 100 maritime countries. By means of the Technical panel two types of estimation were led to detect the determinants of the Liner Shipping Connectivity. A global analysis was led in a first stage. A second analysis based on a geographical decomposition was also led for the same reason. The main examined maritime regions are The Mediterranean Sea, Red Sea, North Sea, Arabian Gulf, and the Caribbean Sea. The UNCTAD's database over the period 2007-2014 was used. UNCTAD's Liner Shipping Connectivity Index is the endogenous variable. Ten explanatory variables are used to explain the variation of the LSCI. Among it, six variables represent the logistic performance. The fourth rest variables are container transit time, container transport cost, the gross domestic product, and containers per capita. This study could be used to explain the density level of liner shipping connectivity between countries in a global and a regional context. Results show that all explanatory variables have a positive impact on the liner shipping connectivity, but with obvious differences in studied maritime regions worldwide. Findings can help decision-makers to determine the priorities for future investments in the maritime sector and the related activities.

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1. Introduction

Seaport is defined as the interface linking sea and land. Nevertheless, its role in the economy is very important. It represents an integral platform serving as a base for production, load and unloading of goods, transshipment of goods, and logistic services. The seaport staff tries to have an important connectivity to achieve its economic functions. A high level of connectivity guarantees the maximum of sea traffic and creates dynamism in the seaport and in the economy. Each seaport hopes to have more levels of shipping connectivity, which depends on maritime companies' choices and their seaport selection criteria.

Recently, the study of liner shipping connectivity (LSC) has drawn more attention from researchers such as Wang et al. (2016), Sun and Zheng (2016), Fugazza et al. (2015) and Jiang et al. (2015). Measurement of liner shipping connectivity offers

several advantages. Zaman et al. (2015) indicated that network of connectivity can be used as a measure to study the performance of the transportation system that will help decision-makers to prioritize investment in transport and decided termination. UNCTAD (2015) indicated that liner shipping connectivity plays a crucial role in determining of trade performance not only for coastal countries but also for landlocked countries. The UNCTAD has the initiative to measure the liner shipping connectivity of nation in the world through calculation of the liner shipping connectivity index (LSCI). This is defined as the indicator which captures how well countries are connected to global shipping networks. The UNCTAD's LSCI is calculated based on five components of the maritime transport sector: The number of ships, their container-carrying capacity, maximum vessel size, number of services, and the number of companies that deploy container ships in a country's ports. As the calculation of UNCTAD's LSC is only based on components of the maritime transport sector and on the assumption that other factors can influence the LSC we raise the question: Did liner shipping connectivity, depend on outside factors to the maritime sector?

This paper examines some seaport selection criteria in order to understand the dynamics of liner shipping connectivity in global analysis and in

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<https://doi.org/10.21833/ijaas.2019.11.002>

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particular on the level of the most important maritime regions in the world: Mediterranean Sea, Red Sea, North Sea, Arabian Gulf, and the Caribbean Sea. We note that maritime region is defined as a geographical zone with a group of seaports together serving the region. The aim of this research is to study the determinants of liner shipping connectivity. We try in particular to show the relationship between the LSC and the following factors: the logistics performance, the container transit time, the container transport cost, the gross domestic product, and the containers per capita in order to identify the most important factors affecting the level of liner shipping connectivity.

The following sections are organized as follows: Next section presents the literature review; section 3 presents the methodology, section 4 presents the data, section 5 presents the empirical results, and section 6 for the conclusion.

2. Literature review

The topic of liner shipping connectivity study took place for the first time through studies concerned by seaport selection criteria. Previous studies conducted indirectly to analyze liner shipping connectivity time through studies concerned by seaport selection criteria. [Slack \(1985\)](#) has examined the selection criteria by investigating the containerized traffic between the Western Europe and the North Midwestern United States. The author concludes that among all analyzed factors the price and service are more important than others. [Tiwari et al. \(2003\)](#) mentioned that the distance from the origin to destination, port congestion, and the shipping line's fleet size constitutes the decisive factors in the seaport selection decision. [Malchow and Kanafani \(2004\)](#) concluded that location is the major factor in the seaport selection decision. Other factors have been listed by [Tongzon and Heng \(2005\)](#), as port operation efficiency level, cargo handling charges, reliability and adaptation to the changing market environment. [Ugboma et al. \(2006\)](#) showed that shipping companies and shippers place a high emphasis on efficiency, frequency of ship visits and adequate infrastructure. The last finding was partially confirmed by [Tongzon \(2009\)](#), which concluded that seaport efficiency, adequate infrastructure, and location are the central factors adopted by the shipping companies in the seaports selection process.

Furthermore, the mentioned studies, we observed some researchers interested directly to the topic of seaport connectivity. [Wilmsmeier et al. \(2006\)](#) showed that inter-seaport liner connectivity has important effects on international maritime transport costs. [Wilmsmeier and Hoffmann \(2008\)](#) analyzed the impacts of seaport infrastructure and liner shipping connectivity on intra-Caribbean freight rates. Authors concluded that structure of liner shipping services, port infrastructure endowment and liner shipping freight rates are closely related to each other. [Fugazza et al. \(2015\)](#)

have studied shortest liner shipping routes between any pair of countries for a reference sample of 178 countries over the 2006-2012 periods. Their results support the fact that the quality of maritime connectivity is likely to be a preponderant determinant of foreign market access. [Hoffmann \(2005\)](#) had the initiative to calculate the Liner Shipping Connectivity Index (LSCI) for 162 coastal countries, which was published since 2007 by the United Nations Conference on Trade and Development (UNCTAD).

[Hoffmann \(2012\)](#) indicated that LSCI is generated from five components: number of companies, the size of the largest ship, and the number of services that connect country's ports to other countries, the total number of ships that are deployed on services and the total container carrying capacity of the ships that provide services. The author indicates that each one five components could be considered an influential indicator on the country's connectivity. [Low et al. \(2009\)](#) indicated that explicit configurations of carriers' networks and shipping routes provide a direct assessment of port connectivity. [Tang et al. \(2011\)](#) established the connectivity index to determine the main elements of port service networks, including port charge, a number of port calls, cargo traffic, trade volume, and other quality attributes, such as turnaround time, operating hours, and inter-modal transport capabilities. [Jiang et al. \(2015\)](#) indicated that seaports which provide reliable, efficient and economical services prove to be more attractive to both shipping companies and shippers. Moreover, they mention that shipping companies can often reroute services to take advantage of superior port services. They indicate that in general, the higher connectivity level of a seaport makes it more attractive in terms of facilitating the transportation of cargo and reducing transportation cost and transit time. Besides, the high seaport connectivity level can strengthen the individual contribution of seaports to the maritime transportation network. Inversely, for a seaport which has a low connectivity level, its contribution to the network is accordingly relatively less.

[Wei and Sheng \(2017\)](#) investigated the import and export logistics connectivity of Chinese inland provinces along the Maritime Silk Road by constructing a complex generalized maritime logistics network that connects inland provinces with seaports along it. Findings show firstly consideration of the cooperative relationship between dry ports and seaports enables the establishment of an import and export logistics network for inland provinces to connect to the Maritime Silk Road, and the implementation of import and export logistics functions of the provinces. Secondly, the logistics connectivity level of China's inland provinces in the overall Maritime Silk Road network is relatively low; it therefore fails to meet the international trade development needs of inland regions.

3. Methodology

The literature did not focus on some other factors that we believe so important to influence the liner shipping connectivity. Our paper included other factors outside of the maritime sector to investigate the concept of liner shipping connectivity. It has the originality to discuss the relationship between the liner shipping connectivity and the following factors: logistics performance (represented by six variables

such as: Ability to track and trace consignments, ease of arranging competitively priced shipments, frequency with which shipments reach consignee within scheduled or expected time, competence and quality of logistics services, efficiency of customs clearance process, quality of trade and transport-related infrastructure), container transit time, container transport cost, the gross domestic product, and containers per capita. Determinants of liner shipping connectivity were shown in Fig. 1.

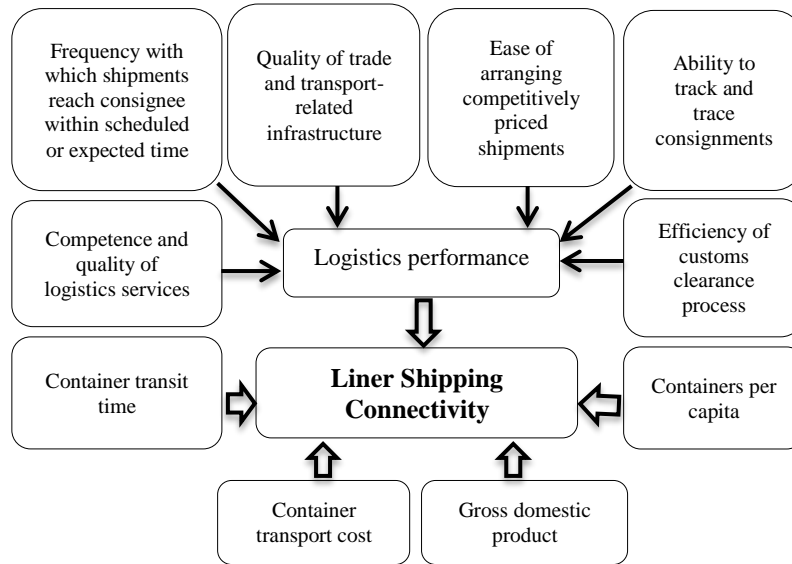


Fig. 1: Determinants of liner shipping connectivity

The hypothesis of this study could be presented as follows:

- **H1:** It has a significant positive relationship between the logistics performance and liner shipping connectivity.
- **H2:** It has a positive relationship between container transit time and liner shipping connectivity.
- **H3:** It has a positive relationship between container transport costs and liner shipping connectivity.
- **H4:** It has a significant positive relationship between the gross domestic product and liner shipping connectivity.
- **H5:** It has a significant positive relationship between containers per capita and liner shipping connectivity.

Based on these Hypotheses, we proposed to determine the impact of the logistics performance, container transport costs, container transit time, containers per capita, and gross domestic product on liner shipping connectivity using the model below.

$$LSC_{it} = \alpha_0 + \alpha_1 LP_{it} + \alpha_2 GDP_{it} + \alpha_3 CTT_{it} + \alpha_4 CTC_{it} + \alpha_5 CPC_{it} + \varepsilon_{it} \quad (1)$$

where, LSC denotes liner shipping connectivity. It measures by UNCTAD's LSCI; witch captures how well countries are connected to global shipping networks. LP denotes logistics performance. It

measured by the World Bank's logistics performance index (LPI) overall score. Witch reflects perceptions of a country's logistics based on six dimensions: ability to track and trace consignments, ease of arranging competitively priced shipments, frequency with which shipments reach consignee within scheduled or expected time, competence and quality of logistics services, efficiency of customs clearance process, quality of trade and transport-related infrastructure. It ranges from 1 to 5, with a higher score representing a better performance (Arvis et al., 2014). GDP denotes gross domestic product. CTT denotes container transit times. It is measured by the average time to export and to import. It measures the period required to fulfill all procedures necessary to export/import goods. It is recorded in calendar days. CTC denotes container transport costs. It is measured by the average cost of export and import for a twenty-foot container. CPC denotes container per capita. It is measured by the ratio of container port traffic to the population. The subscripts *t* and *i* denote respectively the temporal and country index. The exponent's $\alpha_1; \dots; \alpha_5$ are slope coefficients measured by the rate of change in the endogenous variable when there is a unit change in the value of explanatory variables. The exponent α_0 is the intercept coefficient that shows the rate at which LSC will change independently of stated explanatory variables. Finally, ε is the error term, which shows that other explanatory factors that might affect the magnitude of the LCS that are not allowed in the model.

To normalize the data and to reduce the impact of the asymmetric distributions (scores, numbers of containers, USD, time) equation (1) was subjected to a logarithmic transformation. The empirical model to be estimated is derived as:

$$\ln(LSC_{it}) = \alpha_0 + \alpha_1 \ln(LP_{it}) + \alpha_2 \ln(GDP_{it}) + \alpha_3 \ln(CTT_{it}) + \alpha_4 \ln(CTC_{it}) + \alpha_5 \ln(CPC_{it}) + \varepsilon_{it} \quad (2)$$

where; Ln denotes natural logarithms. The equation (2) could be estimated in two levels. Firstly, the total sample (maritime 100 nations) was estimated by the technical of the panel data. Secondly, the sample was decomposed to five maritime regions: Mediterranean Sea: Among the 23 Mediterranean countries the study was interested in 14: Algeria, Croatia, Cyprus, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Slovenia, Spain, Tunisia, and Turkey). The rest of nations were excluded from the empirical analysis because of their incomplete data. Arabian Gulf: Among the seven states of the Arabian Gulf only Iraq was excluded from the empirical analysis because of their incomplete data. Caribbean Sea: For this region, the study was interested in Colombia, Costa Rica, Dominican Republic, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, and Venezuela. The rest of nations was excluded from the empirical analysis because of their incomplete data. North Sea: the region's six states included are Belgium, Denmark, France, Germany, Netherlands, and the United Kingdom. Red Sea: Among the region's eight countries Eritrea was excluded from the empirical analysis because of their incomplete data.

Equation 2 was again esteemed for every zone by the technical of the panel data.

4. Data and descriptive statistics

In this study, we use a sample of 100 maritime nations (some nations such as Iraq, Libya and other are excluded from the empirical analysis because their available data is not complete). The data consist of the different variables, such as liner shipping connectivity (LSC), logistics performance (LP), container transit times (CTT), container transport costs (CTC), gross domestic product (GDP), and container per capita (CPC). The data is collected from The UNCTAD's database over a period of 8 years from to with a number of 800 pooled observations. Since 2007, Logistics performance index (overall score) became provided only every two years. Consequently, missing data concerning this variable is completed by the mean between the last and the previous observations. Table 1 provides descriptive statistics of the variables for the sample period 2007 to 2014.

The calculated mean of LSC for different nations over the considered period is about 30 points and varying from 1.6 points and 165 points proving that the majority of maritime nation have lower values. The LP variable is characterized by a low variability justified by a value of standard deviation about 0.5

points. The individuals in the sample are very heterogeneous concerning the CTC variable expressed by a great value of standard deviation of 489.65 USD.

Table 1: Descriptive statistics for different variable of the study

Variable	Mean	Standard Deviation.	Min	Max
LSC	30.8501	28.13458	1.6	165.0498
LP	3.018215	0.552702	1.793333	4.2
CTT	17.79456	9.819915	5	69
CTC	1180.297	489.65	391.5	3592.5
GDP	1.42e+14	7.81e+14	5.14e+09	8.57e+15
CPC	0.382122	0.991931	0.00048	7.026804

Table 2 provides the linear correlation coefficients between different pair of the considered variables. These values indicate that generally, the correlation between different explanatory variable is low. On the other hand, we note some acceptable negative and positives correlations between the explained and explanatory variables indicating that the regression model could be applied.

Table 2: Correlation matrix

	LSC	LP	CTT	CTC	GDP	CPC
LSC	1					
LP	0.5257	1				
CTT	-0.3688	-0.7089	1			
CTC	-0.2724	-0.3801	0.5032	1		
GDP	0.3279	0.0945	0.1207	-0.011	1	
CPC	0.3980	0.4976	-0.6143	-0.4185	-0.2608	1

5. Empirical results

In this study, the considered model is expressed by the equation (2) above. We estimate this model firstly using the entire sample component, after that re-estimate it by maritime region. The estimation results are provided by Table 3.

For the global estimation, Table 3 shows a significant relationship between the estimated factors and the liner shipping connectivity. Among the five considered explanatory variables, four were significant at 1 % there are CTT, CTC, GDP, and CPC. The LP is significant at 5%. This result allows accepting in a global frame all the previously considered hypotheses H1 to H5. In the same way, all the explanatory factors have a positive impact on the liner shipping connectivity in exception of container transit times which has a negative impact.

When we estimate the model by maritime regions, the estimation results, show that the impact of the five estimated factors on the liner shipping connectivity according to the geographical region is not largely modified comparing to the estimation by the global sample estimation in exception of North Sea region and Arabian Gulf which are characterized by some estimated coefficient greater than the others region. When we interest to the estimation results by maritime region, we deduce the following remarks:

- The logistics performance is significant at the 1% level for the North Sea and at the 10% level for

Mediterranean Sea, Arabian Gulf, and Caribbean Sea. This result confirms that the logistics performance could be considered as determinant of liner shipping connectivity in the maritime regions worldwide. Then, the first hypothesis could be accepted for such regions except the Red Sea.

- For the container transit time, appear as a determinant of the maritime connectivity only for two regions. Then, it is significant at 5% and 10% respectively, for the Mediterranean Sea and the Arabian Gulf. Therefore, H2 could be accepted for these regions and rejected for the others.
- The container transport cost is significant at the 1% level for the Caribbean Sea, and the North Sea and at 5% and 10% respectively for the Red Sea and the Mediterranean Sea. Consequently, this

result confirms that the third hypothesis could be accepted for these regions and rejected only for the Arabian Gulf.

- The Gross Domestic Product is significant at the 1% level for the Mediterranean Sea; at 5% both in the Arabian Gulf and Red Sea; and at 10% for the North Sea. Thus, H4 could be accepted for these regions and rejected only for the Caribbean Sea.
 - The container per capita is the most significant factor on the maritime connectivity for all the studied regions. It is significant at the 1% level for the Mediterranean Sea, the Caribbean Sea and the Red Sea; and at 10% level for the Arabian Gulf. Therefore, the fifth hypothesis could be accepted for these regions and rejected just for the North Sea.

Table 3: Regression results

	Entire sample	By maritime region					
		Mediterranean Sea	Arabian Gulf	Caribbean Sea	North Sea	Red Sea	
constant	-1.789** (0.777)	-5.137** (2.317)	16.511*** (4.268)	-1.871 (1.329)	-25.296*** (6.606)	-3.767 (2.663)	
LP	0.310** (0.147)	0.726* (0.414)	-7.468*** (1.639)	0.574* (0.321)	7.770*** (1.844)	-0.173 (0.255)	
CTT	-0.353*** (0.076)	-0.537** (0.254)	-3.601*** (0.593)	-0.007 (0.124)	-0.007 (0.480)	0.011 (0.180)	
CTC	0.287*** (0.070)	0.508* (0.286)	-0.386 (0.562)	0.424*** (0.131)	1.443*** (0.552)	0.407** (0.170)	
GDP	0.145*** (0.021)	0.238*** (0.064)	0.265*** (0.053)	0.060 (0.038)	0.327* (0.192)	0.210** (0.087)	
CPC	0.237*** (0.031)	0.323*** (0.079)	-0.226 (0.192)	0.197*** (0.060)	0.220 (0.140)	0.557*** (0.108)	
R ²	Within	0.193	0.273	0.216	0.379	0.063	0.5809
	Between	0.391	0.653	0.837	0.468	0.912	0.3452
	Overall	0.379	0.600	0.710	0.461	0.735	0.3515
FE vs RE	74.32	19.7	40.71	50.51	26.3	40.57	
Prob	0.000	0.000	0.000	0.000	0.000	0.000	
Haus.chi2	20.51	2.17	-	2.39	-	7.51	
Prob	0.001	0.825	-	0.793	-	0.1857	

(***), (**), and (*) denotes that the parameter is statistically significant respectively at 1%, 5% and 10%. The number between parentheses denotes the standard error relative to the estimated parameter

6. Conclusion

This study attempts to identify the determinants of the liner shipping connectivity in the maritime regions worldwide. The empirical results conclude that most explanatory variables have a positive impact on the liner shipping connectivity with obvious differences in studied maritime regions. The results showed also that the Container Transport Costs, the Container Transit Times, the Gross Domestic Product, and the Container per Capita are the most influential factors on the liner shipping connectivity in the different regions of the study. However, the logistics performance is considered as the least influential factor on the liner shipping connectivity.

The paper makes significant contributions to the maritime economics literature. Firstly, it confirms empirically the positive role of the logistics performance in the development of maritime connectivity. Results provided relatively an empirical framework that supports the view that saying that logistics performance is essential to the development of maritime connectivity. The direct linkage between logistics performance variables (Quality of trade and transport-related

infrastructure, Competence and quality of logistics services, Efficiency of customs clearance process, Ease of arranging competitively priced shipments, Frequency with which shipments reach the consignee within the scheduled time, and Ability to track and trace consignments) and maritime connectivity has rarely been investigated and this study attempts to fill this gap. Secondly, this study also examines the influence of variables outside of logistics performance on the liner shipping connectivity in the world and in each maritime region. The study found a positive relationship between liner shipping connectivity and both a Gross Domestic Product, Container Transit Times, Container Transport Costs and Container per Capita.

The present study's originality is that it analyzes the liner shipping connectivity in different maritime regions worldwide. Furthermore, based on the researcher's knowledge about the research matter the study is one of the few studies that attempted to analyze the determinants of the liner shipping connectivity in the most maritime regions worldwide. The results of this study can be used to interpret the density level of liner shipping connectivity between countries. The study can help decision makers to make more effective decisions

about the future of investments in the maritime sector and the related activities in order to reinforce the competitiveness and to attract ships.

Like each work, this research suffers from some limitations. Indeed, there is not a clear measure allowing the classification of countries on the basis of the importance of its geographical location in the world. Further studies are needed to reveal the importance of countries' geographical location in the shipping connectivity. Also, the study could be extended to the panel dynamic by introducing the lag of the liner shipping connectivity as an exploratory variable.

Acknowledgment

The author would like to thank the Northern Border University (Kingdom of Saudi Arabia) for supporting this work.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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