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The impact of liner shipping bilateral connectivity on bilateral trade flows : a case of the Republic of Korea

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THE IMPACT OF LINER SHIPPING BILATERAL CONNECTIVITY ON BILATERAL TRADE FLOWS: A CASE OF THE REPUBLIC OF KOREA

By

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the reward of the degree of

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature):

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Supervised by:

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Supervisor's affiliation…….

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Abstract

Title of Dissertation: The Impact of Liner Shipping Bilateral Connectivity on Bilateral Trade Flows: A Case of the Republic of Korea.

Degree: **Master of Science**

Enhancing maritime connectivity facilitates national trade, and better maritime connectivity reduces transport costs substantially. Since, the global supply chain tie-up the whole world through the liner shipping network, the liner shipping connectivity has emerged as a critical area for countries that intend to improve their trade competitiveness.

This research aims to examine the impact of liner shipping bilateral connectivity on the Republic of Korea's bilateral trade flows. To identify the relationship between liner connectivity and trade; the research used the gravity model. Besides, to the Liner Shipping Bilateral Connectivity Index (LSBCI)[1] and four sub-components data of liner connectivity, this research considers the effect of sea distance, nominal gross domestic product (GDP), and the Free Trade Agreement (FTA) of 74 partner countries in the trade.

The results show that LSBCI has a more significant influence on the trade flows than sea distance and nominal GDP. Among the sub-components of liner connectivity, the number of direct services and the number of companies providing direct services positively affect the value of exports. At the same time, the carrying capacity of liner services has a strong impact on the value of imports. Notably, the largest vessel size deployed on direct service positively affects all trade flows. The result indicates that the Republic of Korea takes advantage of an economy of scales, as the significant number of ultra-large vessels are calling at Busan Port with a high cargo utilization ratio.

In conclusion, FTA has a positive effect on the value of exports with LSBCI. The result shows that improving the shipping connectivity with signing an FTA can be a profitable strategy for countries. The findings indicate that, even in distant countries, strengthening of liner shipping connectivity positively affects the value of trade flows. Therefore, to facilitate trade, countries should strive to improve their maritime connectivity.

KEYWORDS: Liner Shipping Bilateral Connectivity (LSBCI), Bilateral trade flows, The Republic of Korea, Gravity model, Cross-sectional regression.

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[1] Published by the United Nations Conference on Trade and Development (UNCTAD)

Table of Contents

List of Tables

List of Figures

List of Abbreviations

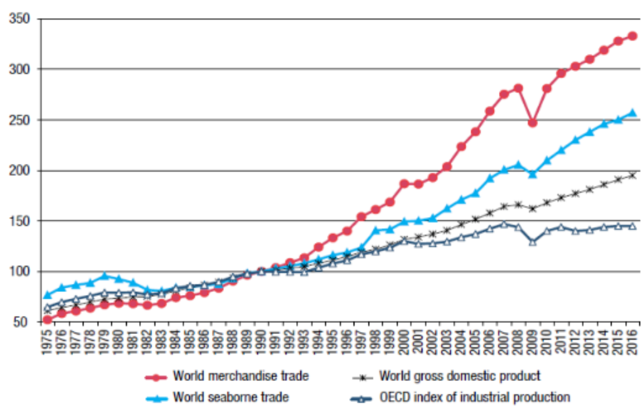
ASEAN	The Association of Southeast Asian Nations
BAF	Bunker adjustment factor
BPA	Busan Port Authority
CAF	Currency adjustment factor
CIF	Cost, Insurance, and Freight
FTA	Free Trade Agreement
GDP	Gross Domestic Product
LPI	Logistics Performance Index
LSBCI	Liner Shipping Bilateral Connectivity Index
LSCI	Liner Shipping Connectivity Index
OLS	Ordinary Least Square
SITC	United Nations Standard International Trade Classification
TEU	Twenty foot Equivalent Unit
Triple-E	Economy of scale, energy-efficient and environmentally improved vessel
UN Comtrade	United Nations Commodity Trade Statistics Database
UNCTAD	United Nations Conference on Trade and Development

1. Introduction

1.1 Maritime transport and connectivity

International trade regarded as an essential means for nations to achieve economic growth beyond the limits of their given resources. As maritime transport handles more than 80% of international trade by volume and over 70% by value (UNCTAD, 2017), maritime transport is considered a core part of international trade. Figure 1 shows that over the last couple of decades, world merchandise trade has significantly increased than the world gross domestic product. Specifically, the world seaborne trade has played a pivotal role in the growth of international trade.

Figure 1. Growth Indexes of Production, World GDP, Seaborne and Merchandise Trade



Source: Review of Maritime Transport 2017 (UNCTAD, 2017)

During the last few decades, the role of maritime transport has changed because of two main drivers: globalisation and containerisation.

Traditionally, the role of shipping was only transportation of cargo from the port of origin to the port of destination. Ports were also regarded as a place where ships come alongside the berth and load and discharge cargo (Stopford, 2008). Nevertheless, with the advent of the maritime logistics concept with the maritime transport (i.e., shipping and ports), ports are no longer just a nodal point for handling cargo in the globalised world. Moreover, the liner shipping has also evolved to meet the complex requirements of customers in the global supply chain by providing reliable, frequent, and regular service based on a published schedule (Ducruet and Notteboom, 2012; UNCTAD, 2017). Ports have evolved as crucial nodes in the global supply chain, which provide multi-modal service and value-added service (Paixao and Marlow, 2003a; Panayides and Song, 2009). Global business has become an essential strategy for enterprises that want to expand their business and reduce total costs. Companies, therefore, need maritime transport as a critical element to manage their global supply chain effectively and efficiently. Under this global supply chain world, companies have become the main driver for international trade. As the role of the countries has changed from the main driver to the facilitator and supporter, the factors that represent the trade competitiveness of the country in relation to maritime transport has also expanded from productivity to connectivity (Arvis et al., 2018).

In this context, maritime connectivity is defined as a "country's position in the liner shipping network" (Fugazza and Hoffmann, 2017). In other words, The maritime connectivity is the indicator which shows a country's connectivity (or integration) through ports in the global liner shipping network.

This study is related to liner shipping connectivity, which is regarded as a combined outcome of maritime transport (i.e., ports and shipping) and trade. The liner shipping connectivity and trade are influenced by each other; improvement in the liner shipping connectivity substantially reduces trade costs, and, which eventually increase trade flows. On the other hand, increased trade can generate demand for liner shipping connectivity. Therefore, the liner shipping connectivity can be regarded as an explanatory variable for the trade or vice versa (Hoffmann et al., 2019).

1.2 Research Objective and Questions

This research aims at examining the impact of liner shipping bilateral connectivity on bilateral trade flows in the case of The Republic of Korea (henceforth called South Korea). Besides, to the Liner Shipping Bilateral Connectivity Index (LSBCI) provided by the United Nations Conference on Trade and Development (UNCTAD) at a country level, this research attempts to analyse the relationship between sub-components of Liner Shipping Connectivity Index (LSCI) and trade flows in terms of both value and volume. The four components of the liner shipping connectivity identified as follows

(1) The number of direct liner shipping services between a pair of countries.

(2) The number of liner companies (carriers) providing direct liner shipping services between a pair of countries.

(3) Container carrying capacity (in terms of TEU[2]) deployed on direct liner shipping services between a pair of countries.

(4) The size of a larger vessel deployed on direct liner shipping services between a pair of countries.

South Korea selected as an empirical case. The findings would be valuable since South Korea is one of the significant maritime powerhouse in the world, and the country is depending on the export-led growth.

The below research questions are structured as per the objective of the research.

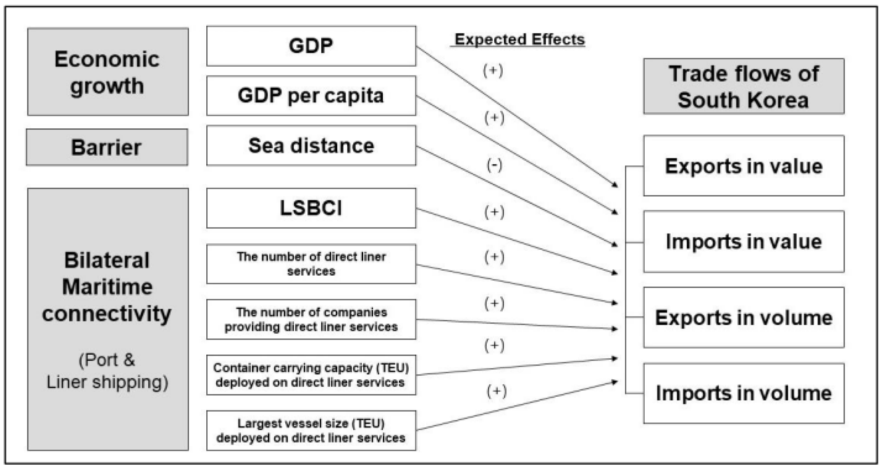
Q1. What is the impact of the Liner Shipping Bilateral Connectivity Index (LSBCI) on the bilateral trade flows of South Korea?

[2] Twenty-foot Equivalent Unit

Q2. What is the impact of each sub-component of the liner shipping connectivity on the bilateral trade flows of South Korea?

Figure 2 shows the research framework. In order to achieve the objectives of the research, the relationship between liner shipping connectivity on bilateral trade flows is examined through an empirical analysis.

Figure 2. Research framework



1.3 Research Contribution

This research makes a multi-fold contribution to both the literature and maritime policymaking. *Firstly*, this research can add diversity to research on the relationship between liner shipping connectivity and trade. Although the importance of maritime connectivity has been widely recognized, very few cases have been analysed by researchers to verify its effects on trade flows (Fugazza and Hoffmann, 2017; Hoffmann et al., 2019; Saeed et al., 2020). Therefore, it would be beneficial to do the research on diverse cases of countries with different characteristics pertaining to maritime transport and trade. Hence, the results of the research are likely to vary depending on individuals characteristics. For instance, South Africa, studied by Hoffmann et al. (2019), and South Korea, —which is the focus of this research,— have different characteristics of maritime transport (further details will elaborate on chapter 4). This research is, therefore, likely to be useful for those researchers who seek for a suitable case for their maritime transport and trade policy and further development.

Secondly, this research can contribute to enhancing the understanding of the contribution of maritime transport,— in particular connectivity,—into the national economy, maritime policymakers. While policymakers are aware of the basic role of maritime transport as a trade facilitator, they are less aware of connectivity from a maritime logistics perspective. Despite the fact that maritime logistics has become a mainstream academic discipline, the perspective of policymakers seems to remain central to ports-only. For instance, in the era of the global supply chain, value creation through integration between players has become an important factor for measuring the competitiveness of ports. Nevertheless, cargo volume and productivity is still regarded as the primary indicator for estimating the competitiveness of ports. In this context, liner shipping connectivity is a prerequisite for assessing the competitiveness of ports from the perspective of the global supply chain. This research not only examines the extent to which shipping and port connectivity affect trade flows but also provides a new perspective on ports competitiveness.

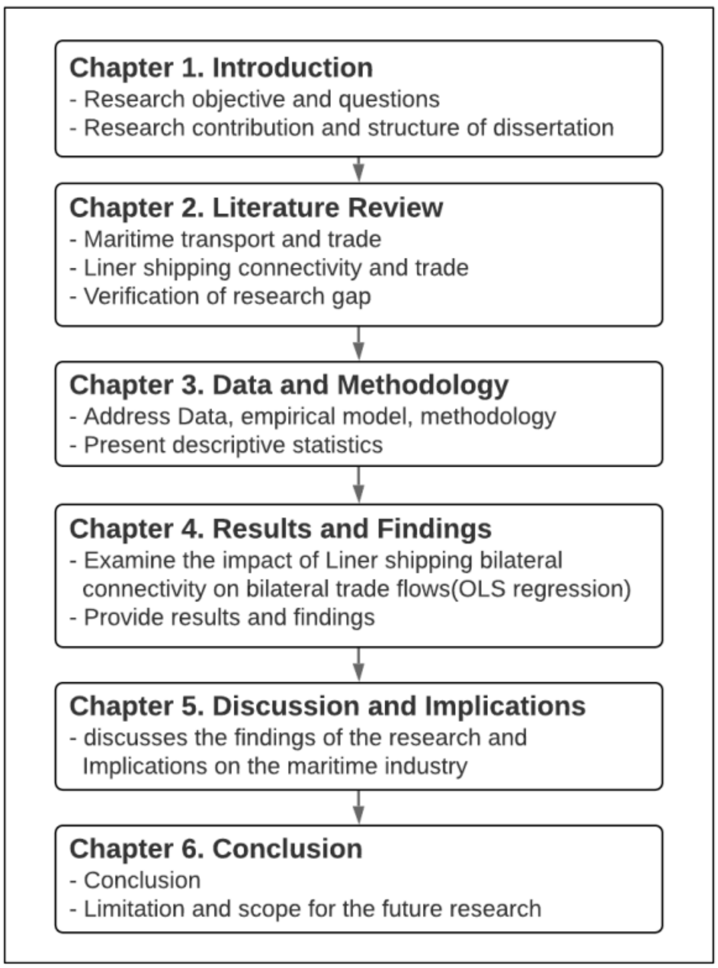
Thirdly, there are very few studies available related to the impact of liner shipping connectivity on trade in South Korea. Thus, this research is likely to present a new perspective on the maritime sector. For example, Busan Port Authority (BPA), which manages South Korea's representative hub port, i.e., Busan port, is making significant efforts to improve liner shipping connectivity. In the case of Busan Port, the liner shipping connectivity index (LSCI) published by UNCTAD seems to be correlates with the increase in the transhipment volumes. However, there are some sceptical views about increase in transhipment volume, as it does not create any benefit to the domestic logistics. Notwithstanding, the increase in the transhipment volume is the result of improved connectivity. Thus, the competitiveness perspective should be changed from volume to connectivity. In this regard, the maritime competitiveness of countries and ports is depending on maintaining the status of centrality on the main lane trade route, and improve connectivity by integrating the global shipping network.

This research supports that the Busan Port Authority (BPA)'s efforts to enhance connectivity contribute to the improvement of the trade competitiveness of shippers.

1.4. Structure of the Dissertation

This dissertation consists of six chapters. Figure 3 depicts the structure of this dissertation. Chapter 1 briefly explain the importance of maritime connectivity for the trade, and then states the objectives and contributions of this dissertation.

Figure 3. Dissertation Structure



Chapter 2 discuss the literature review on maritime transport, connectivity, and trade. It also briefly covered the relationship between martime transport, connectivity, and trade. Moreover, the literature review encompasses various topics on transport costs, maritime infrastructure, maritime connectivity, and its impact on trade costs and trade flows. Subsequently, chapter 2 discussed about the research gap between previous research and the proposed concept in this research. Furthermore, Chapter 3 addresses the source of data used in this research, empirical model, and the research methodology implemented in this dissertation. In the process of getting final results all the variable scrutinized individually. The gravity model, which is earlier used for a cross-sectional Ordinary Least Square (OLS) regression analysis, is applied in this research to analyse the effect of liner shipping bilateral connectivity on bilateral trade flows with 74 trading partners. Finally, descriptive statistics, the result of the correlation between variables, and models are presented for data analysis. Chapter 4 is divided into four parts. The frirst part provide the empirical results of the model used to find the effect of liner shipping bilateral connectivity on bilateral trade flows (i.e., exports and imports) in terms of value and volume. The second part summarises the results and findings of this dissertation. Chapter 5 provides discussion and implications.; this chapter firstly discusses the findings of the research on liner shipping connectivity and trade flows as well as their implications on each player of the maritime industry. Chapter 6 provides the summary and outcome of the dissertation. In the last section research limitations and scope for further research has been presented.

2. Literature Review

2.1. Maritime Transport and Trade

The topic of the relationship between maritime transport and trade has drawn attention from academia and researchers around the world. Researchers have mainly focused on examining the relationship between maritime transport and transport costs or the relationship between maritime transport and trade flows. Hence, transport costs and trade flows have been widely accepted as important variables in maritime transport.

Various researchers have emphasized on the importance of transport costs, infrastructure, and their effects on trade accessibility. For this kind of research, the gravity model, introduced by Tinbergen (1962), has been widely used as a basic model (Clark et al., 2004; Fugazza and Hoffmann, 2017; Helble, 2014a; Martínez-Zarzoso et al., 2003a). The aim of this model is to explain how economic development and (sea) distance affects the trade flow between a pair of countries. Distance is used to represent transport costs as a proxy. (Further details about gravity model discussed in the next chapter.) Thus, transport costs is considered as a trade barrier that prevent access to international markets (Ma, 2020).

Based on the gravity model, Anderson and Van Wincoop (2003) revealed that transport costs amount up to 21% of ad valorem tax, which includes all transport, border-related, and local distribution costs. According to the research of Clark et al. (2004), transport costs are a barrier that is higher than the import tariffs for the Latin American countries to enter into the United States market. Limao and Venables (2001) found that an increase of 10% in transport costs almost reduces 20% in trade volume, these findings are based on shipping data in the United States. These studies were meaningful in providing empirical evidence that transportation costs need to be reduced to increase trade flows. These studies have also instigated to do more research related to ports, in reference to reducing transportation costs in the maritime transport sector.

The importance of port infrastructure in trade facilitation has been widely emphasized in the maritime literature. Haralambides and Veenstra (1996) pointed out that developing countries adopted export-led growth strategies; therefore, the governments in these countries plays a role of a trade facilitator, by reforming port policies successfully. Wilson et al. (2003) found that enhanced port efficiency positively affects bilateral trade flows. Martínez-Zarzoso et al. (2003a) identified that long-distance and low quality of infrastructure increase the transport costs. Investing in the port infrastructure has marginal effects on reducing transport cost and enhancing trade. Limao and Venables (2001) demonstrated that poor infrastructure and geographic features (e.g. landlocked) lead to increase in transport costs substantially, this research was based on shipping cost data between East-North America and the world. They found that a country that has a low quality of transport infrastructure incur 40% more transport cost than required, and similarely the a landlocked countries incur 60% more transport cost than required. These comparisons are based on data received from the coastal countries. Sánchez et al. (2003) found that port efficiency is a crucial determinant of maritime transport costs from the study of Latin American ports. Wilmsmeier et al. (2006) also demonstrated the close relationship between port characteristics and maritime transport costs by studying trade sixteen Latin-American countries. The empirical results showed that four characteristics of ports: i.e., efficiency, infrastructure, private sector participation, and inter-port connectivity significantly affect maritime transport costs. Investment in port infrastructure and private sector participation,—in particular,— give rise to reduced maritime transport costs because it brings advantages of economies of scale and competition amongst shipping lines.

However, despite achievements of ports, the perspective of port competitiveness has to change from the port's operational efficiency to port's integration into the global supply chain (Song and Panayides, 2008a), In alignment with the same, the relationship between maritime transport and trade also need to look from a different perspective.

2.2. Liner Shipping Connectivity and Trade

In the era of globalization, the world is integrated with the global supply chain (Christopher, 2016). Thus, the trade competitiveness of a country should be assessed by how well the country is connected to the global supply chain. The global liner shipping network is the backbone of the global supply chain. Therefore, in the maritime transport and logistics domain, the term "liner shipping connectivity" is a crucial topic for research. In the context of maritime logistics, Hoffmann et al. (2019) determine connectivity as "a position within the liner shipping network". In other words, connectivity can be defined as how well countries or ports are integrated into the global shipping networks.

Along this line, researchers have made efforts to analyse the liner shipping connectivity and its effects on international trade. Wilmsmeier and Hoffmann (2008) analysed the impact of liner shipping connectivity and port infrastructure on intra-Caribbean freight rates. The results show that liner shipping freight rates are closely related to the structure of liner shipping services and port infrastructure. Nevertheless, the distance is traditionally regarded as the main factor in the freight rate and trade competitiveness of countries. However, the empirical results show that transport connectivity,— which is represented as regular and frequent services,— is a statistically more significant factor in trade competitiveness than the distance between two countries. Amongst all the factors, transit time and trade imbalance are precise determinants of transportation costs. The lack of a direct connection between pairs of countries induces higher costs for shippers. Additionally, the competition between shipping lines and a reasonably good level of port infrastructure lead to lower the transport costs. Besides, it is well argued that transport costs which is considered as a portion of the trade cost is much lesser between 'developed' countries than developing countries. The analysis implies that Caribbean countries should try to offer more direct liner shipping services and improve port infrastructure to reduce overall transport costs in the trade.

Through cross-sectional analysis by using sample data of 178 countries, Arvis et al. (2013a) found that the Liner shipping connectivity index (LSCI) and logistics performance index (LPI) are crucial determinants of trade cost. Helble (2014a) also revealed that a direct shipping connection increase trade more than double by using a gravity model approach. Similarely, Petty and Asturias (2012) found that if more shipping lines connects to port, prices dropped and the distance becomes statistically insignificant.

The Liner Shipping Connectivity Index (LSCI) provided by the United Nations Conference on Trade and Development (UNCTAD) is widely used as shipping connectivity index since 2004. The LSCI is a country-level indicator which reflects till what extent countries are integrated into the global liner shipping networks (Jia et al., 2017). The index consists of five elements: number of services, number of shipping companies, number of ships, cargo-carrying capacity, and largest vessel size.

Although the LSCI is a useful indicator to estimate the country's maritime and trade competitiveness,; however, it has its limitations as a single dimension indicator. Since international trade flows (i.e., exports and imports) bilaterally, it deemed necessary to measure the connectivity from a bilateral perspective. Hence, a bilateral index of liner shipping connectivity proposed by Hoffmann et al. (2014).

The Liner Shipping Bilateral Connectivity Index (LSBCI) basically made up of five components. The *first* component is 'the number of transhipments required to get from country *i* to country *j*'. According to Fugazza and Hoffman (2017), amongst more than 130 countries, only 20 percent of countries pairs are directly connected without transhipment. Hence, most of the countries, i.e. almost 80 per cent required to tranship their cargo more than once or twice; the proportion for the one transhipment is 64 per cent and for twice it is 16 per cent. An additional transhipment implies that shippers are required to bear burden of increased time and cost. The risk extent further in terms of delay within the whole transport process. The *second* component of the LSBCI is 'The number of common direct connections between two countries'. It can be simply stated as the more common connections between two countries it is more likely that two countries are well connected with each other. The *third* component of the LSBCI is the geometric mean of the number of direct connections. The purpose of these components is to measure the extent of countries' access in the maritime network between two countries. The *fourth* component of the LSBCI is the level of competition on services that connect country pairs. It can be estimated by the number of carriers that provides the liner shipping services between a pair of countries. A high number in this component indicates a high level of competition, which may lead to a decrease in maritime transport costs. The last component of the LSBCI is the size of the largest ships on the weakest route. The size of the largest ships between a pair of countries represents that the pair of countries not only have efficient port infrastructure to accommodate larger vessels but also have sufficient demand for cargo from the hinterland.

Based on the LSBCI and sub-components data, Fugazza and Hoffmann (2017) demonstrated that bilateral maritime liner shipping connectivity affects exports in manufactured goods by conducting an empirical assessment during the period 2006-2013. The results indicate that improving transport connectivity positively affects bilateral trade. In detail, a lack of direct maritime services leads to a reduction in the value of exports by 40%. A, on the other hand, direct calling of vessels increases the value of export by 5% in the bilateral trade. By Increasing the size of the vessels by 1,000TEU may increase bilateral exports by 1% in terms of value. Their research suggests that a maritime distance can be overestimated in terms of bilateral trade without recognition of the importance of liner shipping connectivity.

Hoffmann et al. (2019) analysed the impacts of liner shipping bilateral connectivity on South Africa's trade flows. The result reveals that the number of direct liner shipping connections, level of competition, and GDP positively affects on the country's trade flows. In contrast, the results also indicate that the number of transhipments and distances have a negative impact on the overall trade flows. The results also reveal that the size of the largest ship is not a significant component in the trade flows. It implies that there is no need for all countries to invest in the port infrastructure to accommodate larger ships as a way to achieve a competitive advantage. Their research also identified that improved transport connectivity affects trade in the long term more than in the short term. This research was an important study to directly examine the effects of bilateral liner shipping connectivity on trade flows. However, the results may vary depending on the characteristics of maritime transport and trade as per individual countries. Therefore, further research is needed on more countries for those who are seeking a case for the development of their maritime transport and trade competitiveness.

2.3. Verification of Research Gaps

Numerous studies have presented the effect of reducing transport costs on trade by using actual data from shipping lines or other organizations (Clark et al., 2004; Limao and Venables, 2001; Martínez-Zarzoso et al., 2003b; Sánchez et al., 2003; Wilmsmeier and Hoffmann, 2008). However, transport costs are difficult to calculate accurately, due to the complicated price structure of liner shipping (Veenstra, 2015). Shipping companies charge miscellaneous fees to their customers such as a bunker adjustment factor (BAF), a currency adjustment factor (CAF), seasonal charge, piracy risk charge, etc. Cariou and Wolff (2006) pointed out that total transport costs increases more than 50% by these surcharges. In comparison, trade flows are more relevant for analysing the direct impacts of liner connectivity on trade. Hence, this research considers actual trade flow data obtained from the UN Comtrade.

Various studies (Arvis et al., 2013b; Clark et al., 2004; Helble, 2014b; Limao and Venables, 2001) used single dimension indicators as explanatory variables, while this research intends to use double dimension indicator such as the LSBC index (UNCTAD), and bilateral liner shipping service data obtained from Alphaliner (calculated by the author) to obtain the final results. With regard to research methodology, Fugazza and Hoffmann (2017) and Hoffmann et al. (2019) used panel data analysis. Therefore, due to the issues of nominal and real value, they estimated the effect of export values alone, rather than volumes. However, since this research uses cross-sectional data analysis, the effect of liner shipping connectivity on trade flows can be measured by export (or import) value and volume as well.

Amongst all studies on the relationship between maritime connectivity and trade, a very few studies have examined the case of an individual country. For instance, Hoffmann et al. (2019) focused on South Africa, Lun and Hoffmann (2016) studied ASEAN countries, and Martínez-Zarzoso et al. (2003b) studied Spain. Therefore, it would be beneficial for the literature to provide diverse research cases of countries with different characteristics for further development.

In this research, South Korea is selected as a case, since South Korea is well known for its export-led growth, and it is a powerhouse in the maritime transport sector. In detail, as per Liner shipping connectivity index (LSCI) South Korea ranked 3rd in the world which indicated that it is an exceptionally well-connected country in the global supply chain. Moreover, it has the world's sixth-largest container port, i.e, Busan port, which is located on the main sea-trade route (i.e., East-West route). In addition, South Korea ranked 7th in terms of ownership of the world fleet by dead-weight tonnage (UNCTAD, 2019).

Since each country has its own characteristics pertaining to maritime transport network and trade, the results of individual researcher are also expected to be different from each case. This case study of South Korea; therefore, will be interesting for countries seeking to improve their trade competitiveness through the development of maritime connectivity.

3. Data and Methodology

3.1. Data and Sources

Cross-section data analysis is widely used to find relationships between variables in trade and macroeconomic research. On the other hand, panel data analysis is also a well-known method for trade and maritime-related econometric research. However, it could not be used for this research because the data related to liner shipping service provided by Alphaliner is only available without time-series. Therefore, a cross-section data analysis method is adopted to estimate the relationship between trade flows and maritime connectivity for this research.

Trade flows data (i.e., imports and exports), in terms of value and volume, of South Korea with its 74 trading partners selected as dependent variables for this research. The data was collected from UN COMTRADE. Among the thousands of trade items, highly containerizable products are selected for the calculation of trade flows in the year 2018. This classification of containerizable products comes from the research of Wilmsmeier et al. (2006) based on the United Nations Standard International Trade Classification, Revision 3, code (SITC rev. 3) (see ANNEX 2 for the list of SITC code).

As independent variables, data of the GDP and GDP per capita of trading partners collected from the UNCTAD statistics. Sea distance between the main ports of the two countries was obtained from sea-distance.org and Alphaliner. The data for Liner Shipping Bilateral Connectivity Index (LSBCI) drawn from the UNCTAD statistics. The raw data for components of Liner Shipping Connectivity obtained from Alphaliner. Then the author calculated bilateral liner shipping service data by regression analysis. South Korea's data for the Free Trade Agreement (FTA) acquired from the Ministry of Trade, Industry, and Energy of the Republic of Korea. Table 1 shows the definition and source of variables.

Table 1. Data and Source

Variable	Unit	Definition	Year	Source
Panel A Dependent variables				
Exports in value	US$ (000s)	Exports in value (highly containerizable products) of South Korea	2018	UN Comtrade
Imports in value	US$ (000s)	Imports in value (highly containerizable products) of South Korea	2018	
Exports in volume	Net weight (ton)	Exports in volume (highly containerizable products) of South Korea	2018	
Imports in volume	Net weight (ton)	Imports in volume (highly containerizable products) of South Korea	2018	
Panel B: Independent variables				
GDP	US$ (current)	Nominal Gross Domestic Product (GDP) of 74 trading countries	2018	UNCTAD
GDP per capita	US$ (current)	GDP per capita of 74 trading countries	2018	
Sea distance	Nautical Miles	Bilateral sailing distance between two main container ports of countries	Na	Sea-distances.org /Alphaliner
LSBCI	Index (0≤LSBCI≤1)	Liner Shipping Bilateral Connectivity Index (LSBCI)	2018	UNCTAD
The number of services	Number	The number of direct liner shipping services between the two countries	2020	Author calculation from Alphaliner
The number of companies providing services	Number	The number of liner companies (carriers) providing direct liner shipping services between two countries	2020	
Container carrying capacity	TEU	Container carrying capacity (TEU) deployed on direct liner shipping services between two countries	2020	
Largest ship size	TEU	Largest ship size deployed on direct services between two countries	2020	
A FTA	0/1	Dummy variable of FTA (1= if the country made the Free Trade Agreement (FTA) into effect on 2018 with South Korea, 0 otherwise)	Na	Ministry of industry, trade and resources

Note: All natural logarithmic values of all the variable (except the dummy variable) is used in the estimation.

3.1.1. Dependent Variables

(1) Exports from South Korea

Table 2 shows exports from South Korea to other countries in terms of value and volume. China is a leading country which comes first on the list in terms of both value and volume, as China has traditionally been South Korea's leading trading partner. The total value of exports from South Korea to China, —including Hong Kong— , is about $270 billion, which is more than the combined export to other 14 largest exporting countries in the year 2018. The United States is ranked third in terms of value with $67 billion, followed by Vietnam ($65 billion) and Japan ($20 billion). In terms of volume of exports from South Korea, China is at the top of the list with US$7 billion followed by the United States (US$4 billion), Vietnam US$2.6 billion), and India US$2.1 billion.

Table 2. Top 15 Countries Exports, 2018

Rank	County	Value (US$000s)	County	Volume (Ton)
1	China	191,009,482	China	7,449,550
2	China, Hong Kong SAR	79,671,340	The United States	4,068,089
3	The United States	67,614,883	Viet Nam	2,632,655
4	Viet Nam	65,515,034	India	2,085,162
5	Japan	20,117,597	Japan	1,823,470
6	Philippines	14,317,021	Turkey	978,359
7	India	13,122,354	Mexico	921,572
8	Mexico	11,257,488	Indonesia	912,316
9	Germany	10,453,069	China, Hong Kong SAR	801,452
10	Singapore	8,617,380	Malaysia	714,151

Source: UN Comtrade
Note: Exports from South Korea to other countries

The top 10 import items to South Korea from other countries, —which are highly containerizable products —, differs in terms of value and volume. With regard to the value of export products, electronic machines is at the top of the list in the table 3, followed by office machines, general industrial machinery, motor vehicle parts, and optical instruments (Table 3).

Table 3. Top 10 items exports from South Korea in terms of value, 2018

Rank	Item	Trade Value (US$ billion)
1	Electr.Machines, Apparatus And Appliances	318
2	Transistors, Valves, Tubes, Etc.	250
3	Office Mach., Autom.Data-Processing Equip	67
4	Office And Adp Machine Parts And Access	53
5	General Indust.Machinery And Equip,N.E.S	42
6	Motor Vehicle Parts And Accessor. N.E.S.	39
7	Optical Instruments And Apparatus	27
8	Electrical Machinery And Apparatus,N.E.S	25
9	Switches, Resistors, Printed Circuits Etc	24
10	Telecom; Sound Recording And Reprod.App.	23

Source: UN Comtrade
Note: Exports from South Korea to other countries

In terms of the volume of export products, plastic products are ranked first in the table 4 followed by paper, chemical products, motor vehicle parts, electrical machinery, and synthetic fibres (Table 4).

Table 4. Top 10 items exports in terms of volume, 2018

Rank	Item	Trade volume (Net weight ton)
1	Other Plastics, In Primary Forms	9,900,344
2	Paper And Paperboard	6,256,479
3	Polymers Of Ethylene	6,130,909
4	Polyethers,Polycarbonates,Polyesters Etc	5,276,970
5	Motor Vehicle Parts And Accessor. N.E.S.	5,107,334
6	Polymers Of Styrene	4,294,174
7	Miscellaneous Chemical Products, N.E.S.	2,173,653
8	Electrical Machinery And Apparatus,N.E.S	2,165,128
9	Plates, Sheets, Film, Foil And Strip	2,012,504
10	Synthetic Fibres Suitable For Spinning	1,888,794

Source: UN Comtrade
Note: Exports from South Korea to other countries

(2) Imports of South Korea

Table 5 shows the top 10 countries from where South Korea Imports multiple products. The table is arranged in terms of value and volume from importing countries. As was expected, China is ranked first in the import table in terms of value and volume. In terms of value of the imports Japan and the United States ranked second and third, respectively, followed by Vietnam, Germany, and Malaysia. With respect to volume, the United States and Japan ranked second and third, in the table, followed by Vietnam, India, and Malaysia.

Table 5. Top 10 countries Imports, 2018

Rank	County	Value (US$000s)	County	Volume (Ton)
1	China	125,848,308	China	7,075,430
2	Japan	41,996,927	The United States	1,548,288
3	The United States	31,464,505	Japan	1,421,119
4	Viet Nam	24,179,364	Viet Nam	893,855
5	Germany	15,174,990	India	787,207
6	Malaysia	8,156,615	Malaysia	726,197
7	Singapore	7,956,147	Thailand	508,297
8	Italy	5,560,641	Germany	470,973
9	France	5,443,201	Indonesia	470,601
10	Thailand	4,870,970	Australia	411,733

Source: UN Comtrade
Note: Imports from other countries to South Korea

The top 10 import items in the table, which are highly containerizable products get imported in South Korea from other countries; this reflects the character of industrial structure of the county. South Korea known for its strong economy with a solid manufacturing industrial base such as shipbuilding, automobile production, telecommunication, electronics, and chemical product. As shown in the Table 6, electrical machinery ranked first in terms of value. other types of machinery, telecommunication equipment and chemical materials also included in the list of top importing items in South Korea.

Table 6. Top 10 imported items in South Korea in terms of value, 2018

Rank	Item	Trade Value (US$ Billion)
1	Electr.Machines,Apparatus And Appliances	128
2	Transistors, Valves, Tubes, Etc	82
3	Office Mach.,Autom.Data-Processing Equip	44
4	General Indust.Machinery And Equip,N.E.S	32
5	Office And Adp Machine Parts And Access.	26
6	Telecom; Sound Recording And Reprod.App.	21
7	Measuring, Checking, Controlling Instrum	20
8	Chemical Materials And Products, Nes	18
9	Adp Machines And Units Thereof	18
10	Telecommunications Equipment	16

Source: UN Comtrade
Note: Imports from other countries to South Korea

Since, South Korea has a solid industrial structure that requires imported raw materials to manufacture the final products which may re-exports from the country. Therefore, many raw materials requires for the manufacturing industries such as aluminium, paper, glass and textiles. Hence, these items are in the list of top imported items in terms of volume. Additionally, some other items such as furniture and beverages, which are status symbol of standard of living in the country are also the part of the top 10 list of imported items in the year 2018.

Table 7. Top 10 imported items in the South Korea in terms of volume, 2018

Rank	Item	Trade Volume (Net weight ton)
1	Aluminum	3,945,854
2	Paper And Paperboard	2,479,684
3	Glass	2,235,802
4	Textile Yarn	1,646,734
5	Other Plastics, In Primary Forms	1,506,894
6	Furniture And Parts Thereof, Bedding Etc	1,313,460
7	Polyethers, Polycarbonates, Polyesters Etc	1,130,073
8	Transistors, Valves, Tubes, Etc.	1,098,681
9	Alcoholic Beverages	979,187
10	Plates, Sheets, Film, Foil And Strip	865,678

Source: UN Comtrade
Note: Import from other countries to South Korea

3.1.2. Independent Variables

(1) Nominal Gross Domestic Product (GDP)

The gross domestic product (GDP) regarded as a crucial indicator that represents the size of the economy of any country. The GDP can be calculated by the total value of goods produced and services provided in a country during a one financial year. In this research, Nominal GDP of 74 countries selected as an independent variable to estimate the effect of liner shipping connectivity on trade flows in the year 2018. It is worth noting that the GDP of the partner country should be considered as an important variable in the gravity model, which is the basic model for this research. Table 8 shows the United States, China, and Japan are the largest economies in the world which are ranked first, second, and third respectively among the top 15 countries in the world. Germany, United Kingdom, France, and India followed in the list. In contrast, islands countries such as Fiji, New Caledonia, and Malta are located in the bottom of Table 8 due to their small economic size and low population, even though their GDP per capita is relatively higher

Table 8. Top and bottom 15 countries: GDP, 2018 (US M$)

Rank	Top 15	US M$	Rank	Bottom 15	US M$
1	The United States	20,681,354	1	Marshall Islands	214
2	China	13,608,152	2	Palau	284
3	Japan	4,971,323	3	Micronesia (Federated States of)	371
4	Germany	3,949,549	4	Tonga	504
5	United Kingdom	2,855,297	5	Samoa	833
6	France	2,786,081	6	Vanuatu	889
7	India	2,779,352	7	Solomon Islands	1,271
8	Italy	2,084,882	8	Togo	5,165
9	Brazil	1,868,613	9	Fiji	5,537
10	Canada	1,712,562	10	New Caledonia	10,174
11	Russian Federation	1,660,514	11	Bahamas	12,425
12	Australia	1,453,871	12	Mauritius	14,220
13	Spain	1,419,735	13	Malta	14,549
14	Mexico	1,223,401	14	Jamaica	15,714
15	Indonesia	1,042,173	15	Papua New Guinea	23,077

Source: UNCTAD statistics

(1) GDP Per Capita

GDP per capita is an important macro-economic indicator that represents the economic level of the country. It is calculated by dividing the GDP of a country by its population. It is, therefore, necessary to take into consideration the GDP per capita and GDP of each country to understand the economic level and size of the country. The GDP per capita of partner countries selected as one of the independent variables in order to identify the relationship with trade flows and liner shipping connectivity between a pair countries. Table 9 shows that Qatar, Singapore, and the United States are ranked first, second, and third in the table, which represents the GPD per capita of the top 15 countries in the world. In particular, although Qatar and Singapore are small countries in terms of population and geographical area, they are among the wealthiest countries in terms of GDP per capita income.

Table 9. Top and bottom 15 countries: GDP per capita, 2018 (US $)

Rank	Top 15	US $	Rank	Bottom 15	US $
1	Qatar	68,794	1	Togo	655
2	Singapore	62,721	2	Pakistan	1,330
3	The United States	62,625	3	Cambodia	1,512
4	Denmark	61,834	4	Solomon Islands	1,947
5	Australia	58,393	5	India	2,055
6	Sweden	55,767	6	Nigeria	2,154
7	Netherlands	53,583	7	Ghana	2,202
8	China, Hong Kong SAR	49,199	8	Egypt	2,538
9	Germany	47,514	9	Viet Nam	2,563
10	Belgium	47,293	10	Papua New Guinea	2,681
11	Canada	46,192	11	Ukraine	2,957
12	Israel	44,215	12	Vanuatu	3,037
13	New Zealand	43,836	13	Philippines	3,103
14	United Arab Emirates	43,005	14	Morocco	3,273
15	United Kingdom	42,366	15	Micronesia (Federated States of)	3,296

Source: UNCTAD statistics

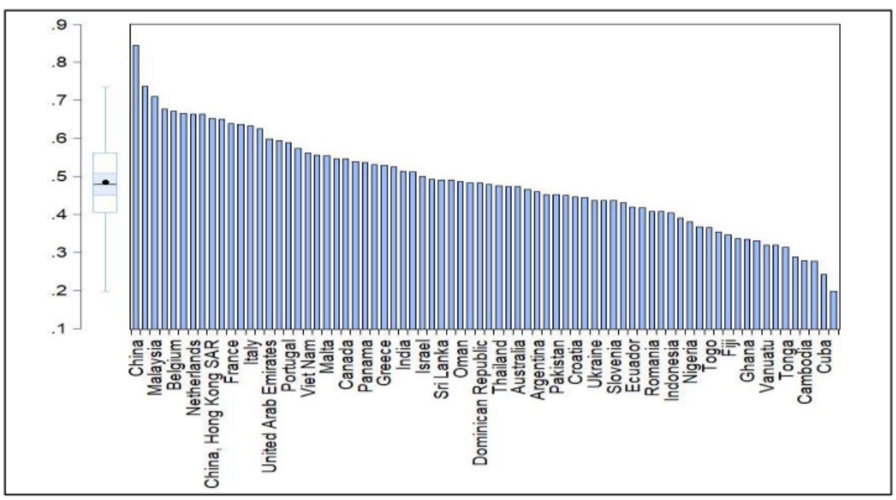
(2) Sea Distance

Sea distance is considered as an essential variable for trade and maritime transport research; because it is widely used as a proxy of transport cost. In the gravity model, the higher the distance between a pair of countries, it is likely that higher the cost of trade between these countries. As a result, it is expected that trade flows between the two countries will decrease eventually. In this research, sea distance means the distance between the two main ports of a pair of countries, For instance, Busan in South Korea and Hamburg in Germany.

(3) Liner Shipping Bilateral Connectivity Index (LSBCI)

Liner Shipping Bilateral Connectivity index (LSBCI) is developed by the United Nations Conference on Trade and Development (UNCTAD) to calculate the connectivity between a pair of countries via the liner shipping network. The LSBCI is made up of five sub-components. 1) The number of transhipments required to get from country *i* to country *j*; 2) The number of common direct connections; 3) The geometric mean of the number of direct connections between each of the two countries; 4) The level of competition on services that connect country pairs; 5) The size of the largest ships on the weakest route. Details of the LSBCI previously discussed in the section of the literature review. Figure 4 shows the LSBCI of South Korea with other countries in 2018.

Figure 4. Liner Shipping Bilateral Connectivity Index (LSBCI) of South Korea



Source: UNCTAD statistics

Note: The LSBCI take values between 0 (minimum) and 1 (maximum)

Table 10 shows top and bottom fifteen countries pertaining to the LSBCI of South Korea. It is evident that the top 15 countries have common features: (1) these are mostly developed countries in Europe or Asia; (2) all these countries are located on the major sea trade route (e.g., East Asia – Europe or North America); (3) almost every country contains a high quality of maritime logistics infrastructure such as ports, road, and rail. Hence, these features indicates that these countries have (1) direct liner shipping connections, (2) fierce competition between carriers, which may bring the quality of services to customers, (3) exceptionally high quality of ports infrastructure with a sufficient capacity to accommodate ultra large container vessels which carries more than 20,000 TEU. On the other hand, bottom 15 countries are mostly island countries, which do not have economic hinterlands around them, or these are developing countries which are away from the main sea trade route.

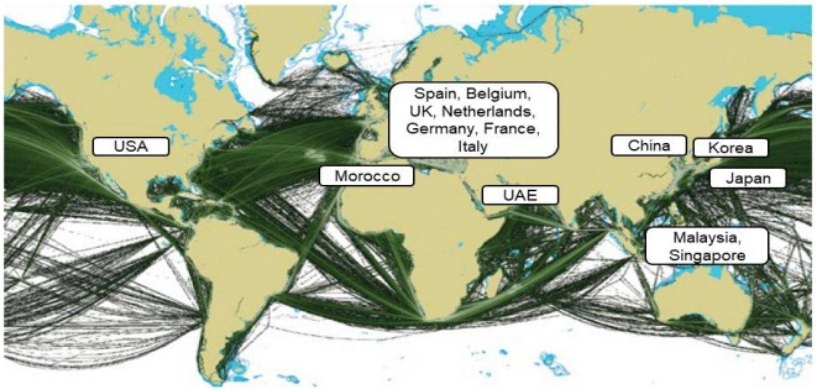
Table 10. Top and bottom 15 countries: LSBCI of South Korea, 2018

Rank	Top 15 Country	Index	Bottom 15 Country	Index
1	China	0.8442	Palau	0.1976
2	Singapore	0.7367	Cuba	0.2410
3	Malaysia	0.7104	Micronesia (Federated States of)	0.2762
4	Spain	0.6765	Cambodia	0.2790
5	Belgium	0.6718	Samoa	0.2873
6	United Kingdom	0.6665	Tonga	0.3123
7	Netherlands	0.6646	Marshall Islands	0.3180
8	Germany	0.6633	Vanuatu	0.3188
9	China, Hong Kong SAR	0.6515	Papua New Guinea	0.3299
10	United States of America	0.6510	Ghana	0.3336
11	France	0.6387	Solomon Islands	0.3352
12	Japan	0.6367	Fiji	0.3458
13	Italy	0.6325	New Caledonia	0.3544
14	Morocco	0.6258	Togo	0.3654
15	United Arab Emirates	0.5976	Mauritius	0.3669

Source: UNCTAD statistics
Note: Index from 0 to 1

Figure 5 presents the top 15 countries connected with South Korea as per LSBCI, based on the density map of container ships, 2016. It verifies the aforementioned common features such as developed countries, located on the major sea trade route, i.e., East to West; and the high quality of maritime logistics infrastructure.

Figure 5. Top 15 countries located on the density map of containership movement



Source: Review of Maritime Transport 2017 (UNCTAD, 2017)
Note: The author put the name based on the density map of the container movement via ships

(4) The Number of Direct Liner Shipping Services

The number of direct services between the two countries is a bilateral indicator that represents the maritime connectivity between a pair of countries. The concept of this indicator comes from one of the sub-components of the Liner Shipping Connectivity Index (LSCI) provided by UNCTAD. However, since the original indicator is a unilateral indicator that represents the liner shipping connectivity of a single country, the researcher calculated the number of direct services between the two countries using Alphaliner data to get a bilateral indicator. This indicator implies that shippers of two countries are conveniently able to transport their cargo at a reasonable price in comparison with competitors which have no direct liner shipping services. Table 11 shows that China is ranked on top, provided with 185 direct liner-shipping services. There are several reasons. China is (1) The second-largest economic country in terms of GDP; (2) The most connected country in terms of Liner Shipping Connectivity; (3) The most prominent trade partner with South Korea in terms of both exports and imports; (4) Geographically close to South Korea (i.e., low transport costs); (5) Has the quality of port infrastructures sufficient for accommodating large vessels and handling cargo. Furthermore, Japan ranked second provided with 78 liner shipping services due to the short distance between the two countries and the interdependency of the two countries' economies. Countries located on the main trade route (e.g., Singapore, Malaysia, Panama), and those with relatively large economies (e.g., The United States, Russia, Germany) are reported on the top in the list of 15 countries.

Table 11. Top and bottom 15 countries: the number of direct liner services

Rank	Top 15 Countries	No	Bottom 15 Countries	No
1	China	185	Ukraine	1
2	Japan	78	Jordan	1
3	China, Hong Kong SAR	61	Micronesia (the Federated States of)	1
4	Singapore	44	Samoa	1
5	Viet Nam	43	Dominican Republic	1
6	Malaysia	33	Cuba	1
7	The United States	28	Mauritius	1
8	Thailand	19	Romania	1
9	Panama	15	Palau	1
10	Russian Federation	12	Portugal	1
11	Saudi Arabia	11	Bahamas	1
12	Germany	10	Sweden	1
13	United Kingdom	9	Denmark	1
14	Netherlands	9	Qatar	1
15	Indonesia	8	Others	1

Source: Author's calculation based on data from Alphaliner
Note: No denotes the number of direct liner services with South Korea

(5) The Number of Liner Shipping Companies Providing Direct Service

The number of liner shipping companies providing direct service between a pair of countries is an indicator of how many carriers are competing with each other on the same route. In other words, this variable represents the level of competition on liner shipping services. Similar to the previous variable, the concept of this indicator comes from one of the sub-components of the Liner Shipping Connectivity Index (LSCI) provided by UNCTAD. However, since the original indicator is also a unilateral indicator that represents the liner shipping connectivity of a single country, the researcher calculated the number of carriers providing direct service between the two countries using Alphaliner data to get a bilateral indicator. In general, the higher the number of carriers in services, the higher the competition. Besides, it is clear that adequate competition brings high quality and reduces costs substantially.

Table 12. Top and bottom 15 countries: the number of liner shipping companies

Rank	Top 15 Countries	No	Bottom 15 Countries	No
1	China	60	Mauritius	1
2	Japan	48	Portugal	3
3	China, Hong Kong SAR	35	Bahamas	3
4	Singapore	34	Nigeria	3
5	Malaysia	30	Ghana	3
6	Viet Nam	29	Cambodia	3
7	Thailand	23	Micronesia (the Federated States of)	4
8	Philippines	20	Jordan	4
9	United Arab Emirates	18	Samoa	4
10	Oman	18	Cuba	4
11	Sri Lanka	17	Palau	4
12	Indonesia	16	Sweden	4
13	Canada	16	Denmark	4
14	United States of America	16	Qatar	4
15	Ecuador	15	Lebanon	4

Source: Author's calculation based on data from Alphaliner
Note: No denotes the number of liner shipping companies providing direct service with South Korea

Table 12 shows the top and bottom 15 countries in terms of the number of liner shipping companies providing direct service with South Korea. Amongst the top 15 countries, most are Asian countries. This is because managing liner shipping services requires a substantial operating cost and a group of vessels in order to secure a fixed regular schedule (i.e., weekly service) regardless of whether the ships are fully loaded or not (Ma, 2020). For instance, Intra-Asia liner services (e.g., Korea-Japan) can be operated by only one or two vessels within two days, while long-haul services (e.g., Far East – Europe) are required to deploy 12 vessels to provide regular weekly service due to the long duration of the journey (e.g., 84 days / 12 vessels = 7 (weekly service)).

(6) **Container Carrying Capacity (TEU) Deployed on Direct Liner Shipping Services**

Container carrying capacity deployed on direct liner shipping service is an indicator that represents a country's trade competitiveness on the supply side. The source of the concept of this indicator, the method of calculation, and the source of the data is similar as those of the previous indicators. This variable implies that a large carrying capacity on direct liner service provides shippers with opportunities to transport cargo with sufficient space at a low price. Table 13 shows the top and bottom 15 countries regarding container carrying capacity on direct liner service with South Korea.

Table 13. Top and bottom 15 countries: container carrying capacity

Rank	Top 15 Countries	TEU	Bottom 15 Countries	TEU
1	China	7,911,665	Micronesia (Federated States of)	1,804
2	Singapore	4,091,226	Palau	1,804
3	Malaysia	3,219,404	Samoa	3,624
4	China, Hong Kong SAR	2,742,587	Cuba	3,624
5	United States of America	2,274,733	Marshall Islands	8,272
6	Germany	1,759,256	Vanuatu	10,092
7	Japan	1,683,536	Tonga	10,092
8	Panama	1,537,847	Fiji	10,092
9	Viet Nam	1,379,724	Solomon Islands	11,952
10	Saudi Arabia	1,358,072	Papua New Guinea	17,562
11	United Kingdom	1,324,413	New Caledonia	18,420
12	Spain	1,303,814	Cambodia	20,889
13	Netherlands	1,266,569	Jordan	39,795
14	Morocco	1,202,562	Russian Federation	58,176
15	India	1,012,569	Bahamas	67,989

Source: Author's calculation based on data from Alphaliner
Note: TEU denotes total container carrying capacity deployed on direct liner shipping services with South Korea

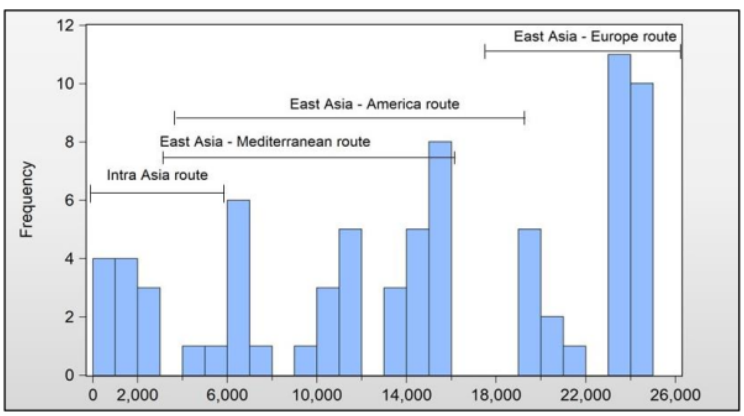
The top 15 countries are mostly located on the main East-West trade route (i.e., Asia – Europe or America), on which ultra-large vessels are mainly deployed by major shipping lines that pursue the hub-and-spoke model of operations. Besides, those countries have the quality of ports that play a role as a hub or main gateway serving their hinterland. In contrast, The bottom 15 countries are mostly island countries with small economies (e.g., Micronesia, Palau, Samoa, Marshall Islands).

(7) **Largest vessel size (TEU) of ships deployed on direct services**

Largest vessel size on direct service is an indicator that represents both trade and maritime ability of the country. The source of the concept of this indicator, the method of calculation, and the source of the data are the same as those of the previous indicators. The size of the largest container ships indicates that the country has better port infrastructures and high cargo demand to attract larger vessels. From the shipping line's perspective, the objective of deploying a larger vessel is to take advantage of economy of scale to reduce the per-unit operating cost (Cullinane and Khanna, 2000). Despite the risk of not being able to load the cargo fully, the majority of shipping lines that provide deep-sea service have been striving to deploy ultra-large vessels. In order for shipping lines to expand their geographical cover and reduce costs, horizontal integration between shipping lines (i.e., consolidation, alliance) has become an essential strategy under a fierce market (Frémont, 2009; Song and Panayides, 2002).

In addition, from the perspective of ports, restructuring the shipping network by deploying larger vessels and fewer ports of calls has put enormous pressure on the container terminal. Ports are required to not only invest in infrastructure but also improve their cargo handling capability. Thanks to its outstanding ports (i.e., Busan, Incheon, Kwangyang), South Korea has been responding well to this trend of changes in the shipping market. Figure 6 illustrates the largest vessel size for direct liner shipping service to/from South Korea. It can be seen that container ships of various sizes ranging from 670 TEU on the Intra-Asia route to 24,000TEU on the Far East-Europe route were deployed on the liner shipping service.

Figure 6. Largest ship size deployed on direct services with South Korea



Source: Author's calculation based on data from Alphaliner

3.2. Gravity Model and OLS Regression Analysis

The gravity model is adopted for this research. The gravity model is known as the most common model for estimating trade flow and spatial interaction research (Rodrigue et al., 2013; Veenstra, 2015). In addition, it has been widely used in various categories of research (e.g., traffic flows, migration) due to the expandability of research that can be applied, including other explanatory variables. The gravity model comes from Newton's law of gravity. According to Newton's theory, the attractive force between two objects is proportional to their mass and inversely proportional to the distance between them (Anderson, 2011). The basic formula of the gravity model based on Newton's theory is that the trade volume between the two countries is proportional to the GDP of two countries and inversely proportional to the distance between the two countries (Rodrigue et al, 2013). Thus, the gravity model can be expressed as an equation as follows.

Equation 1:

$$T_{ij} = \mathrm{A} \cdot \frac{Y_i \, Y_j}{D_{ij}}$$

Where,

T_{ij} : *The volume of trade between country i and country j*

Y_i : *GDP of country i*

Y_j : *GDP of country j*

D_{ij} : *Distance between country i and country j*

A : Proportional constant

In this research, Ordinary Least Square (OLS) analysis with the log-linear model is applied. Then the following extended equation can be obtained by including other determinants affecting the trade between two countries.

$$lnT_{ij} = ln\alpha + \beta 1 lnY_i + \beta 2 lnY_j + \beta 3 lnD_{ij} + \varepsilon_{ij}$$

ε_{ij} represents other determinants that are affecting the trade between two countries as mentioned above. In this research, Liner shipping bilateral connectivity index (LSBCI), and four indicators related to the liner shipping connectivity are applied to analysis as determinants. In the logarithm equation above, the parameter value β means elasticity. In other words, the parameter value β represents the percentage change for trade between the two countries when the independent variables change by one per cent.

Using the data set in table 14, regression equations estimated by ordinary least square (OLS) are as follows:

- Equation A: Value of Exports

$$E_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LSBCI_{ij} + \beta_4 FTA_{ij} + \varepsilon_{ij} \qquad \text{Eq. A1}$$

$$E_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 ND_{ij} + \beta_4 FTA_{ij} + \varepsilon_{ij} \qquad \text{Eq. A2}$$

$$E_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 NC_{ij} + \beta_4 FTA_{ij} + \varepsilon_{ij} \qquad \text{Eq. A3}$$

$$E_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 CC_{ij} + \beta_4 FTA_{ij} + \varepsilon_{ij} \qquad \text{Eq. A4}$$

$$E_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LS_{ij} + \beta_4 FTA_{ij} + \varepsilon_{ij} \qquad \text{Eq. A5}$$

- Equation B: Value of Imports

$$I_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LSBCI_{ij} + \varepsilon_{ij} \qquad \text{Eq. B1}$$

$$I_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 ND_{ij} + \varepsilon_{ij} \qquad \text{Eq. B2}$$

$$I_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 NC_{ij} + \varepsilon_{ij} \qquad \text{Eq. B3}$$

$$I_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 CC_{ij} + \varepsilon_{ij} \qquad \text{Eq. B4}$$

$$I_{ij}^{V} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LS_{ij} + \varepsilon_{ij} \qquad \text{Eq. B5}$$

- Equation C: Volume of Exports

$$E_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LSBCI_{ij} + \varepsilon_{ij} \quad \text{Eq. C1}$$

$$E_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 ND_{ij} + \varepsilon_{ij} \quad \text{Eq. C2}$$

$$E_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 NC_{ij} + \varepsilon_{ij} \quad \text{Eq. C3}$$

$$E_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 CC_{ij} + \varepsilon_{ij} \quad \text{Eq. C4}$$

$$E_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LS_{ij} + \varepsilon_{ij} \quad \text{Eq. C5}$$

- Equation D: Volume of Imports

$$I_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LSBCI_{ij} + \varepsilon_{ij} \quad \text{Eq. D1}$$

$$I_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 ND_{ij} + \varepsilon_{ij} \quad \text{Eq. D2}$$

$$I_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 NC_{ij} + \varepsilon_{ij} \quad \text{Eq. D3}$$

$$I_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 CC_{ij} + \varepsilon_{ij} \quad \text{Eq. D4}$$

$$I_{ij}^{M} = \alpha + \beta_1 GDP_j + \beta_2 Kn_{ij} + \beta_3 LS_{ij} + \varepsilon_{ij} \quad \text{Eq. D5}$$

Where, E_{ij}^{V} indicates the export value of highly containerisable products from country i to country j; I_{ij}^{V} indicates the import value of highly containerisable products from country i to country j; E_{ij}^{M} indicates the export volume of highly containerisable products from country i to country j; I_{ij}^{M} indicates the import volume of highly containerisable products from country i to country j; GDP_j denotes Nominal Gross Domestic Production for country j; Kn_{ij} represents the sea distance in nautical miles[3] between country i to country j; $LSBCI_{ij}$ is Liner

[3] The distance between the two main ports of countries i and j are used as the distance between the countries.

shipping bilateral connectivity index between country i and j; ND_{ij} is the number of direct liner shipping services between country i and j; NC_{ij} is the number of companies (carriers) providing direct liner shipping services between country i and j; CC_{ij} is container carrying capacity (TEU) deployed on direct liner shipping services between country i and j; LS_{ij} is Largest ship size deployed on direct liner shipping services between country i and j; FTA_{ij} is the dummy variable representing the free trade agreements between countries i and j, that is, if their exist a free trade agreement, then the variable will take value one, and will take value zero otherwise. All natural logarithmic values of all the variable (except the dummy variable) is used in the estimation.

3.3. Data description

Table 14 shows the descriptive statistics of all variables applied in the analysis. In this research, the value and the volume of trade flows are set as dependent variables, respectively, in order to estimate the effect of liner shipping connectivity.

Table 14. Descriptive Statistics (South Korea)

Variables	Mean	Median	Std. Dev.	Max	Min	Obs
Panel A Dependent variables						
E_{ij}^{V}	7,599,387	501,655	25,861,864	191,000,000	144.877	74
I_{ij}^{V}	4,155,021	183,640	15,886,966	126,000,000	0.349	74
E_{ij}^{M}	430,262	103,577	1,048,780	7,449,550	72.523	74
I_{ij}^{M}	228,760	11,298	858,134	7,075,430	0.001	74
Panel B: Independent variables						
GDP_j	1,036,132	242,847	2,921,841	20,681,354	214	74
$GDP_{capita\ j}$	19,891	11,298	19,480	68,794	654	74
Kn_{ij}	6,714	7,522	3,248	11,608	492	74
$LSBCI_{ij}$	0.4863	0.4801	0.1275	0.8441	0.1976	74
ND_{ij}	10	3	24	185	1	74
NC_{ij}	11	9	10	60	1	74
CC_{ij}	693,949	232,342	1,150,282	7,911,665	1,804	74
LS_{ij}	14,202	14,500	7,994	24,000	670	74
FTA_{ij}	-	-	-	1	0	74

Note: See Table 1 and explanation in page 32-33 for the definition of the variables. Eviews is used a software for statistics and regression analysis.

Due to the high correlation between independent variables related to liner shipping connectivity (See table 15), the coefficients of the model were estimated by adding variables respectively to the basic gravity model.

Table 15. Correlation test of independent variables

Variables	GDP_j	$GDP_{capita\ j}$	Kn_{ij}	$LSBCI_{ij}$	ND_{ij}	NC_{ij}	CC_{ij}	LS_{ij}
GDP_j	100%							
$GDP_{capita\ j}$	28%	100%						
Kn_{ij}	-16%	12%	100%					
$LSBCI_{ij}$	44%	46%	11%	100%				
ND_{ij}	57%	10%	-43%	54%	100%			
NC_{ij}	44%	16%	-51%	62%	88%	100%		
CC_{ij}	58%	22%	-27%	72%	89%	83%	100%	
LS_{ij}	25%	42%	25%	82%	33%	46%	54%	100%

Note: See Table 1 and explanation in page 32-33 for the definition of the variables

4. Results and findings

4.1. The impacts of Liner shipping connectivity on the value of Exports

The empirical analysis, as explained in the previous chapter, was based on cross-sectional data with 74 countries, which have liner shipping services directly connected to South Korea. An ordinary least square regression (OLS) approach was used to analyse how the Liner Shipping Bilateral Connectivity (LSBC) index and related indicators, the partner country's GDP and per capita GDP, and Sea distance between two representative ports affect Korea's trade flow (i.e., exports and imports) in terms of value and volume. In addition, the FTA dummy variable was applied to analyse the effect of the FTA. Table 16 shows the result of analysis by considering exports in terms of value as a dependent variable.

Table 16. Results of estimated coefficient of the value of exports

variables	[A] Eq A1	[B] Eq A2	[C] Eq A3	[D] Eq A4	[E] Eq A5
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Dependent variables = E_{ij}^{V}					
GDP_j	0.8902***	0.8993***	0.9003***	0.8199***	0.8978***
Kn_{ij}	-0.8820***	-0.5704**	-0.6217**	-0.9205***	-0.9867***
$LSBCI_{ij}$	1.1949*				
ND_{ij}		0.3526**			
NC_{ij}			0.5556**		
CC_{ij}				0.3099***	
LS_{ij}					0.3589**
FTA_{ij}	0.7056**	0.6863**	0.7118**	0.6523**	0.7151**
constant	10.6212	6.4410	6.1467	7.0979	7.2031
observations	74	74	74	74	74
Adj. R2	0.8742	0.8767	0.8786	0.8851	0.8763

Notes: *** 99% significance level, ** 95% significance level, * 90% significance level

[A] Equation A1: consisted of GDP of partner country, Sea distance, LSBC index, FTA dummy

[B] Equation A2: consisted of GDP of partner country, Sea distance, the number of direct services, FTA dummy

[C] Equation A3: consisted of GDP of the partner country, Sea distance, the number of companies providing direct liner services between two countries, FTA dummy

[D] Equation A4 consisted of GDP of the partner country, Sea distance, container carrying capacity (TEU) deployed on direct liner services between two countries, FTA dummy

[E] Equation A5: consisted of GDP of the partner country, Sea distance, largest vessel size (TEU) of ships deployed on direct liner services between two countries, FTA dummy

This result empirically demonstrates the assumption of gravity theory and previously associated research. On the other hand, GDP per capita is not statistically significant in all models. It indicates that liner shipping connectivity affects the size of the economy (i.e., GDP) rather than the level of income (i.e., GDP per capita). Although this result is not consistent with the research of Anderson (1979), which estimated that an increase in incomes would increase trade volume, it is difficult to compare the two results due to the difference in the type of analysis and other variables.

As illustrated in Equation A1, the LSBC index is statistically significant at the 90% level, and has a positive effect on exports in terms of value. Furthermore, an increase in the Liner Shipping Bilateral Connectivity Index (LSBCI) of 1% leads to an increase in the value of exports of 1.1%, which has a greater impact than GDP (0.89%), Sea distance (-0.88%), and FTA dummy (0.70%). This result indicates that despite the negative effect of the distance between two countries, the size of the economy (i.e., GDP) on the demand side and improved liner shipping connectivity (i.e., LSBCI) on the supply side could have a greater impact on the increase in the value of exports. This result is consistent with Hoffmann et al. (2019) ‘s findings.

Among the analysis results of other variables related to liner connectivity, the number of shipping companies providing direct services between two countries (Equation A3 in Table 16) was found to have the greatest effect on the value of exports at 0.55% of elasticity. It indicates that a 1% increase in the level of competition increases of the value of exports by 0.55%. This is in line with the general research findings that competition leads to lower transport costs, which contributes to an increase in trade flows. In addition, other variables (i.e., the number of direct services (Equation A2, 0.35%), Carrying capacity (Equation A4, 0.30%), and the size of the largest vessel (Equation A5, 0.35%) were also found to have a positive effect on the value of exports.

4.2. The impacts of Liner shipping connectivity on the value of Imports

Table 17 shows the result of analysis by considering the value of imports as a dependent variable. Notably, the FTA dummy variable was found to be statistically insignificant in all other models except for the above value of exports model, so the model was estimated without the FTA variable. It is interesting to note that the beta coefficient of LSBCI of imports (2.04) is greater than that of exports (1.19 or 1.48: if the FTA dummy variable is included), even though the R^2 of imports (0.78) is less than that of exports (0.87). Amongst independent variables, carrying capacity is statistically significant and has a strong (3.09) effect on imports in terms of value.

Table 17. Results of estimated coefficient of value of imports

variables	[A] Eq B1	[B] Eq B2	[C] Eq B3	[D] Eq B4	[E] Eq B5
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Dependent variables = I_{ij}^V					
GDP_j	1.1179***	1.2278***	1.2655***	1.1036***	1.0753***
Kn_{ij}	-0.9783***	-0.7550**	-0.8876***	-1.0136***	-1.2262***
$LSBCI_{ij}$	2.0474*				
ND_{ij}		0.243633			
NC_{ij}			0.1707		
CC_{ij}				3.0949*	
LS_{ij}					0.8335***
constant	8.2350	3.1168	3.7814	3.0949	1.6169
observations	74	74	74	74	74
Adj. R2	0.7812	0.7736	0.7718	0.7828	0.7962

Notes: *** 99% significance level, ** 95% significance level, * 90% significance level

[A] Equation B1: consisted of GDP of the partner country, Sea distance, LSBC index

[B] Equation B2: consisted of GDP of the partner country, Sea distance, the number of direct services

[C] Equation B3: consisted of GDP of the partner country, Sea distance, the number of companies providing direct liner services between two countries

[D] Equation B4 consisted of GDP of the partner country, Sea distance, container carrying capacity (TEU) deployed on direct liner services between two countries

[E] Equation B5: consisted of GDP of the partner country, Sea distance, largest vessel size (TEU) of ships deployed on direct liner services between two countries

Liner Shipping Bilateral Connectivity index (Equation B1, 2.04), Carrying capacity (Equation B4, 3.09) and largest ship size (Equation B5, 0.83) are statistically significant and have an effect on the value of imports when estimated independently, while the number of direct services (Equation B2) and the number of companies providing direct service (Equation B3) are not associated with the value of imports. In line with the assumption of the gravity model, GDP and Sea distance are statistically significant at the 99% level.

4.3. The impacts of Liner shipping connectivity on the volume of Exports and Imports

Table 18 shows the result of analysis by considering the volume of exports as a dependent variable. As can be seen in Tables 18 and 19, the Liner Shipping Bilateral Connectivity Index (LSBCI, Equation C1, and D1) is statistically insignificant with the volume of exports and imports. This result demonstrates that enhancing liner shipping connectivity is only statistically significant and has a positive effect on the value of exports and imports in South Korea. Even though carrying capacity and largest vessel size are statistically significant, their beta coefficients (0.21, 0.29) are much smaller than other results on the value of exports and imports (Table 18)

With regard to the volume of imports on South Korea represented in Table 19, all independent variables are statically insignificant except the largest vessel size. Even the R^2 of this variable shows the lowest results (0.59) among the equations in this research. It is important to note that the variable largest vessel size is statistically significant and has a positive effect on all models (i.e., exports and imports, value and volume).

Table 18. Results of estimated coefficient of exports in the volume

variables	[A] Eq C1	[B] Eq C2	[C] Eq C3	[D] Eq C4	[E] Eq C5
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Dependent variables = E_{ij}^{M}					
GDP_j	0.9531***	0.9306***	0.9415***	0.8623***	0.9057***
Kn_{ij}	-0.5664***	-0.3928**	-0.4466**	-0.5951***	-0.6580***
$LSBCI_{ij}$	0.3628				
ND_{ij}		0.1983			
NC_{ij}			0.2585		
CC_{ij}				0.2121**	
LS_{ij}					0.2999*
constant	4.8145	3.035750	3.084726	3.2578	3.1185
observations	74	74	74	74	74
Adj. R2	0.8734	0.8758	0.875360	0.8822	0.8792

Notes: *** 99% significance level, ** 95% significance level, * 90% significance level, refer to below notes for table 19

Table 19. Results of estimated coefficient of imports in the volume

variables	[A] Eq D1	[B] Eq D2	[C] Eq D3	[D] Eq D4	[E] Eq D5
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Dependent variables = I_{ij}^{M}					
GDP_j	1.0500***	1.1111***	1.1251***	1.0049***	0.9522***
Kn_{ij}	-0.9790**	-0.9051*	-0.9531**	-1.0053**	-1.1881***
$LSBCI_{ij}$	0.9580				
ND_{ij}		0.0785			
NC_{ij}			0.043688		
CC_{ij}				0.2214	
LS_{ij}					0.6865*
constant	5.781853	3.5858	3.847098	3.0954	1.6620
observations	74	74	74	74	74
Adj. R2	0.579224	0.5773	0.577139	0.5821	0.5937

Notes: *** 99% significance level, ** 95% significance level, * 90% significance level

[A] Equation C1, D1: consisted of GDP of the partner country, Sea distance, LSBC index

[B] Equation C2, D2: consisted of GDP of the partner country, Sea distance, the number of direct services

[C] Equation C3, D3: consisted of GDP of the partner country, Sea distance, the number of companies providing direct liner services between two countries

[D] Equation C4, D4 consisted of GDP of the partner country, Sea distance, container carrying capacity (TEU) deployed on direct liner services between two countries

[E] Equation C5, D5: consisted of GDP of the partner country, Sea distance, largest vessel size (TEU) of ships deployed on direct liner services between two countries

4.4. Summary

The result indicates that GDP has a positive and significant impact on South Korea's bilateral trade flows of both exports and imports regardless of whether connectivity components are included or not. On the other hand, GDP per capita is statistically insignificant on all trade flows when estimated with connectivity components. It means that liner shipping connectivity is associated with the size of the economy (i.e., GDP) rather than the level of income (i.e., GDP per capita). Sea distance has a negative and significant impact on South Korea's trade flows both exports and imports, in terms of both value and volume.

Concerning liner shipping connectivity variables, The Liner shipping Bilateral Connectivity Index (LSBCI) has a positive and significant effect on South Korea's bilateral trade flows of both exports and imports, but only in terms of value. The results show that a 1% increase of the LSBCI leads to a 1.19% increase in value of exports, estimated with the FTA variable, and to a 2.04% increase in imports, without the FTA variable. However, LSBCI is statistically insignificant when it comes to volume of both exports and imports. This result indicates that improvement in liner shipping connectivity only affects the trade flow in terms of value. The reduction in transhipment and sharing a common route between countries would lower maritime transport costs, which will have a positive effect on the increase in trade flows in value.

Two of the four components of liner shipping connectivity – the number of direct services (ND_{ij}) and the number of companies providing direct services (NC_{ij}) – are only statistically significant in the value of exports. In other words, it can be said that the lack of direct service and competition between carriers may negatively affect exports in terms of value. On the other hand, carrying capacity (TEU) deployed on direct service (CC_{ij}) is statistically significant and has a positive effect on South Korea's trade flows except for imports in terms of volume.

The last variable – largest ship size (LS_{ij}) - is statistically significant, and positively affects all trade flows in both value and volume positively. South Korea is able to accommodate ultra-large vessels of more than 24,00TEU because of its transhipment hub port, Busan Port, which is located on the main trade route with higher infrastructure and service quality. South Korea takes advantage of the economy of scales compared to other countries as most ultra-large vessels of major shipping alliances deployed on the East-West route call Busan Port with a high cargo utilization ratio.

Another interesting finding is that all liner shipping connectivity-related variables are significant only in exports in terms of value. In other words, an increase in 1) The LSBC index; 2) the number of direct shipping services; 3) competition between carriers providing direct service; 4) Carrying capacity (TEU) deployed on direct services; and 5) the size of largest vessel deployed in direct shipping services; all have a positive effect on the increase in exports in terms of value. The R^2 of exports in value also records the highest (87%) among four variables. In addition to the aforementioned effects of the FTA, this result shows that improving liner shipping connectivity can be said to be much more beneficial for countries with an export-driven economic growth strategies.

5. Discussion and Implication

5.1. Discussion

This research aimed to analyse the impact of the liner shipping bilateral connectivity on bilateral trade flows in the case of South Korea. Two research questions were stated to examine this topic. (1) What is the impact of the Liner shipping bilateral connectivity index (LSBCI) on bilateral trade flows of South Korea? (2) What is the impact of each sub-component of liner shipping connectivity on the bilateral trade flows of South Korea?

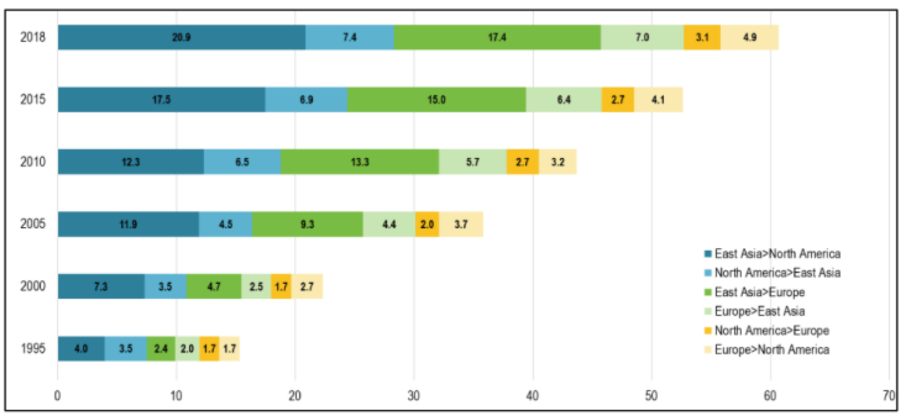
In order to answer these questions, this research developed a research framework that reflects the expected effects of liner shipping connectivity and sub-components on trade flows in both value and volume. The equations based on the gravity model assumed that enhancing liner shipping connectivity affects trade flows positively. In total, twenty ordinary least square (OLS) regression equations were used for analysis. Concerning trade flows other research was conducted on value only, while volume was included in this research.

The results suggest that the liner shipping bilateral connectivity index (LSBCI) positively affects both exports and imports in value. It is worth noting that LSBCI is a more influential factor than GDP and distance. Thus, the findings of this dissertation may indicate that enhancing liner shipping bilateral connectivity (e.g., increasing direct liner service and common connections) has more impact on trade flows in value than the size of the economy and geographical distance. This result is consistent with previous research of Hoffmann et al. (2019) which focused on South Africa.

Regarding the relationship between sub-components and trade flows, this research assumed that all sub-components affect trade flows positively. The results show that both the number of direct services and the number of companies providing direct liner service have positive effects on exports in value. The empirical findings of this dissertation support the concept that the more competition between liner shipping service providers, the lower the transport costs for shippers, which in turn generates more exports in value between the pair of countries.

The carrying capacity (TEU) deployed on direct liner services has a positive effect on bilateral trade flows except for imports in volume. This result seems to indicate that increasing carrying capacity may provide shippers with more opportunity to transport their cargo. In particular, the carrying capacity has a strong impact on imports in value. This finding confirms the fact that transport costs are lower on back-haul than head-haul due to the (a) trade imbalance between supply and demand on the East-West main lane route and (b) utilisation rate of the vessel. In detail, South Korea's main trading partner countries are located on the main lane East-West container trade route, which is well known to have an imbalance between supply and demand. As depicted in Figure 7, the gap between eastbound and westbound containerized cargo flows (i.e., trade imbalance) has steadily increased in the Trans-pacific route and East-Europe route (Rodrigue, 2020).

Figure 7. Containerized cargo flows along Major trade route, 1995-2017



Source: The geography of transport system (Rodrigue, 2020)
Note: In million TEUs

As a consequence of trade imbalance, transport costs vary depending on the direction of trade. On the trans-pacific trade, for example, transport costs of eastbound are higher than that of westbound trade. In addition to the utilisation rate of the vessel, according to the report of Drewry (2019), the utilisation rate for the East-West head-haul recorded 87.0%, while that of East-West back-haul recorded only 45.8% in 2018. Hence, from the viewpoint of South Korea's traders, transport costs for imports are lower than that of exports in general on the East-West route due to trade imbalance. Low transport costs and adding more carrying capacity bring importers to an opportunity to consider importing more products. Of course, other factors that affect the final price of products such as customs and transaction fees and, inland transport costs should be taken into consideration.

Notably, largest ship size is statistically significant and positively affects all trade flows both in value and in volume. Nevertheless, this result is different from that of Hoffmann et al. (2019), who studied South Africa. The reasons are that the subject countries for research are different, and the characteristics of trade and maritime transport of those countries are different as well (Table 20).

Table 20. Comparison of maritime transport statistics between S. Korea and S. Africa

Country	LSCI	Number of arrivals	Median time in port (days)	Maximum container carrying capacity (TEU) of container ships
South Korea	102.8887	20,777	0.60	20,776
South Africa	38.3928	2151	1.64	13,100

Source: Data from UNCTAD statistics, compiled by Author
Note: Container ships only

Based on the containerizable products applied equally to both studies, imports are greater than exports in South Africa in terms of value. In addition, the utilisation rate of the North-South route, which records 66.3% in head-haul and 38.6% in back-haul is relatively low, compared to the East-West route (head-haul 87.0%; back-haul 45.8%) (Drewry, 2019). The result of Haralambides' (2019) research indicate that if the vessel is not fully loaded, economies of scale, in turn, become diseconomies of scale, which seems to be suitable for the case of South Africa. However, South Korea, which is located on the main lane East-West route, seems to achieve economies of scale due to the high utilisation rate on vessels. Hence, these findings support the view that countries that have hub-ports may take advantage of economies of scale by accommodating ultra-large vessels. Nevertheless, from the supply chain perspective, it should be considered that total transport costs are likely to increase due to the fact that congestion in the port and hinterland transport process is caused by ultra-large vessels.

Meanwhile, the results of the gravity model indicator show that the GDP of the trade partners has a positive impact on bilateral trade flows in all models. In addition, distance between a pair of countries affects trade flows negatively. These results confirm the fact that the gravity model has a robust theoretical rationale.

Notably, a Free Trade Agreement (FTA) between a pair of countries is statistically significant and positively affects only exports in value. From the perspective of exports of manufactured products, this result supports the view that the signing of a FTA has a positive influence on the value of exports of South Korea, which pursues an export-driven growth strategy, and provides a rationale for the continued signing of FTAs.

5.2. Implications

In this section, the implications of the research findings on South Korea's maritime industry (i.e., policymakers, port authority and terminal operator) are presented. In addition, it would be a profitable case for other countries that want to benchmark the maritime strategy of South Korea.

Policymakers

The empirical findings of this study indicate that liner shipping connectivity (i.e., maritime connectivity) positively affects trade flows in terms of value. Those results indicate that enhancing maritime connectivity would contribute to trade flows in terms of value, which is beneficial for the national economy. Since maritime connectivity is made up of ports and liner shipping, countries should strive to improve both sides in maritime transport. In this regard, ports play a pivotal role as nodes of the maritime network. From a maritime network perspective, the key is how well countries or ports are integrated into the global supply chain and global shipping network (Bichou & Gray, 2004; Notteboom & Rodrigue, 2008; Song & Panayides, 2008b; Woo et al., 2013). In addition, from the perspective of port users, value creation is recognised as an important competitiveness factor for ports rather than productivity and volume handled (De Martino & Morvillo, 2008; Lam & Song, 2013; Robinson, 2002). Although the increase in export and import volume is slowing, the increase in value through the improvements of the maritime connectivity is meaningful for nations.

Therefore, the competitiveness of ports should be evaluated not by volume, but by connectivity as it underpins value creation. For example, the fact that Busan Port is selected as the main port of call of the major shipping alliance means that Busan Port maintains the centrality of the global logistics network by solidifying its function as a transhipment port, which helps improve the trade competitiveness of domestic import and export shippers. Thus, the hub port plays a crucial role for the nation. This is because how well shippers can access the global network depends on the competitiveness of the hub port. It is important that policymakers should understand the importance of maritime connectivity for the national economy, and should actively support ports to maintain their centrality and connectivity as hub ports through continuous investment and innovation. In particular, the empirical result of this research supports the view that the improvement in maritime connectivity may be helpful to countries that want to benchmark South Korea's export-led growth strategy.

Port authority and terminal operator

The empirical results and findings of this research ensure that ports play a pivotal role as trade facilitators by improving maritime connectivity. In this regard, the strategy of ports should be reconsidered from the port-only perspective to the global supply chain perspective in a way to improve maritime connectivity. Thus, the focus should no longer be on productivity of berths or volume of the container itself, but on connectivity (Wang et al., 2016). In other words, ports should focus on attracting more direct liner services, facilitating competition, and accommodating larger vessels so as to boost their trade flows.

Furthermore, in order to maintain their competitiveness and enhance connectivity, ports should strive to improve not only efficiency in operation but also integrate into the global supply chain operated by the global shipping network. Regarding inter-port relationship, under the hub-and spoke concept, as Lam and Yap (2011) suggests, hub ports located on the main East-West route have a complementary relationship. Therefore, hub ports are required to cooperate with each other so as to be connected within the same global shipping network.

The findings of this research confirm the concept that the size of larger ships deployed on direct liner services between a pair of countries has a positive impact on trade flows due to the effect of the economy of scale. This finding also supports the view that ports are required to invest more in infrastructure to accommodate larger vessels. However, the following questions arise a) how long will this phenomenon continues? b) what is the limit of the containership's size? This is because ports must respond to changes in shipping and at the same time, minimize the amount of large-scale investment.

Interestingly, the current pandemic situation in 2020 is a tough time for everyone, but it gives great lessons to the shipping and port industries. Over the last decade, container lines have competitively introduced the ultra-large vessel in a way to reduce per unit operating costs. Subsequently, they have struggled to fill up the ships and operate the whole network regardless of the lack of demand. That approach was not optimal when it comes to profitability. However, under the pandemic situation, container lines realize how to cope with the lack of demand. The answer is that agile capacity management (e.g., blank sailing and idle ships), which makes container lines more profitable in spite of a drop in demand. For example, Maersk and other carriers, including HMM, Hapag-Lloyd, and ZIM, posted healthy profits thanks to low bunker prices and high freight rates caused by reduced capacity under this unprecedented pandemic situation. (Porter, 2020 August 20)

The approach of Maersk has totally changed during the pandemic crisis compared with the 2009 financial crisis. In 2011, Maersk placed an order for 10 Triple-E class large vessels (18,000TEU), while Maersk has nothing on order at present. It is worth noting that Mr. Søren Skou who is chief executive of Maersk Group stressed in an interview with Lloyd’s list (Porter, 2020 August 20) “We have no plans to change our approach to matching capacity to demand in an agile fashion.” “In 2009, we kept the network operating for a long time and lowered prices to fill a network that was too big. Then, we went aftermarket share, but this time we are focusing on profitability".

Since ports and liner shipping have a symbiotic relationship within liner shipping networks, it is essential to grasp the change of interest of liner shipping companies. In this context, in order to adapt to a change of approach in container lines and cope with this uncertainty, ports should be agile and resilient (Paixao & Marlow, 2003b).

6. Conclusion

6.1. Conclusion

Maritime connectivity represents not only the competitiveness of maritime transport (i.e., ports and shipping) but also the trade competitiveness of the nation. In particular, maritime connectivity is crucial for countries that rely heavily on maritime transport for trade. Since maritime transport carries about 99% of trade flows in South Korea, the competitiveness of maritime transport and its connectivity into the global supply chain are regarded as underpinings to facilitate the economy.

In this context, the aim of this research was to analyse the impact of the liner shipping connectivity on bilateral trade flows in South Korea. The result of regression indicates that the liner shipping bilateral connectivity (LSBC) index is significant and positively affects the value of exports and imports.

Traditionally, sea distance and the size of the country's economy (GDP) were taken into account as the dominant determinants of bilateral trade flows. This was also demonstrated through this research. However, the research findings suggest that the LSBC index has more impact on trade flows in terms of value than distance and GDP. In other words, maritime connectivity has a greater influence than the physical distance and the size of the economy. It can be inferred that if a pair of countries are connected to each other with direct liner services, common connections and, high competition between the carriers, and have an adequate carrying capacity, trade flows will be increased thanks to economies of scale and intensified competition in maritime transport.

The number of direct liner shipping services between two countries (ND_{ij}) and the number of companies providing direct liner shipping services (NC_{ij}) positively affects the value of exports. These results imply that the more competition and options for liner shipping service countries have, the more they can increase exports in terms of value. This is because increased liner shipping service and intensified competition leads to lower transport costs (Haralambides, 2019; Rodrigue & Notteboom, 2013); hence, shippers have an advantage in exporting their products under CIF terms of incoterms. Nevertheless, it should be aware that the supply and demand of the shipping market have an absolute influence on transport costs. Even with this in mind, the effects of these two variables are meaningful in themselves.

Notably, largest ship size (TEU) deployed on direct service between a pair of countries (LS_{ij}) is statistically significant and positively affects both value and volume of trade flow. This result is dissimilar to the research of Hoffmann et al. (2019), which focused on the case of South Africa. This is because the two countries have different characteristics of liner shipping connectivity. While South Africa is located on the North-South route, South Korea is located on the East-West route, which shows high utilization of vessels, deployed by ultra-large container ships. Hence, South Korea seems to take advantage of economy of scale. Nevertheless, more research is needed on diseconomy of scale in which additional costs and time are incurred for the entire supply chain, including ports.

The effect of the Free Trade Agreement (FTA_{ij}) is statistically significant and has a positive effect on the value of exports when estimated together with the LSBC index. This result shows that strengthening liner shipping connectivity and signing an FTA can be a useful strategy to increase the value of exports for countries that have adopted an export-led growth strategy.

The findings of this research indicate that, even in distant countries, the strengthening of liner shipping connectivity has a positive effect on increasing trade flows in value. (i.e., directly linked via liner service, competition between carriers, sufficient carrying capacity, the effect of the economy of scale through larger vessels). Therefore, in order to facilitate trade, nations should strive to improve their maritime connectivity.

6.2. Limitations

Nonetheless, there are some limitations to this research. Regarding the number of observations, this dissertation was unable to encompass countries that have no direct liner service with South Korea. In spite of the effort to estimate all liner service, the global liner shipping network is too complex to calculate all transhipment services in the scope of this dissertation. Hence, other sub-components of LSBCI such as 'the number of transhipments required to get from country A from country B', 'the number of direct connections common to both country A and country B' could not be taken into account.

All data were obtained from Alphaliner. Despite the fact that Alphaliner provides valuable data on liner shipping service, it is available at present without time-series data. Hence, the analysis of this dissertation is limited to finding the relationship between variables over time.

6.3. Scope for future research

This research can be expanded for further research as follows:

This dissertation focuses on the case of South Korea. Since maritime connectivity is a relative concept, comparative analysis methodology would be useful to compare the connectivity of different countries as a way to recognize the position of each country. For instance, further research could extend the target countries for comparative analysis. Countries for the research could be classified by the level of income (i.e., high income, upper middle income, low income) and, the level of maritime connectivity. Therefore, further research may contribute to the literature by enriching diverse findings of connectivity.

This dissertation examines the impacts of the liner shipping bilateral connectivity on bilateral trade flows in South Korea. However, it does not cover all connectivity for the entire logistics chain. Liner shipping connectivity is just one part of trade connectivity, which is made up of three dimensions: maritime connectivity, port efficiency, and hinterland connectivity (Arvis et al., 2018). Therefore, connectivity between modes of transport would be an interesting sector for further research.

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Appendices

Appendix A. 74 Countries that have direct liner shipping services with South Korea

Argentina	Israel	Portugal
Australia	Italy	Qatar
Bahamas	Jamaica	Romania
Belgium	Japan	Russian Federation
Brazil	Jordan	Samoa
Cambodia	Lebanon	Saudi Arabia
Canada	Malaysia	Singapore
Chile	Malta	Slovenia
China	Marshall Islands	Solomon Islands
China, Hong Kong SAR	Mauritius	South Africa
Colombia	Mexico	Spain
Croatia	Micronesia (Federated States of)	Sri Lanka
Cuba	Morocco	Sweden
Denmark	Netherlands	Thailand
Dominican Republic	New Caledonia	Togo
Ecuador	New Zealand	Tonga
Egypt	Nigeria	Turkey
Fiji	Oman	Ukraine
France	Pakistan	United Arab Emirates
Germany	Palau	United Kingdom
Ghana	Panama	United States
Greece	Papua New Guinea	Uruguay
Guatemala	Peru	Vanuatu
India	Philippines	Viet Nam
Indonesia	Poland	

Appendix B. List of SITC codes used in the data of this dissertation

The following commodities are used for empirical research. It follows the classification of the United Nations Standard International Trade Classification, Revision 3, Code (SITC rev. 3). See https://unstats.un.org/unsd/classifications/Econ/Download/In%20Text/CPCprov_english.pdf for more details on the individual codes. This dissertation only includes commodities with a high probability of containerizations.

High probability of containerizations. 111, 112, 12, 121, 122, 16, 17, 212, 22, 261, 263, 264, 266, 267, 268, 289, 35, 37, 48, 515, 525, 531, 532, 533, 541, 542, 551, 553, 554, 56, 57, 571, 572, 573, 574, 575, 58, 581, 582, 583, 59, 593, 597, 598, 611, 612, 613, 62, 621, 625, 629, 633, 64, 641, 642, 651, 652, 653, 654, 655, 656, 657, 658, 659, 664, 665, 666, 667, 681, 683, 684, 685, 686, 687, 689, 694, 695, 696, 697, 733, 735, 737, 74, 74, 741, 742, 743, 744, 745, 746, 747, 748, 749, 75, 751, 752, 759, 76, 761, 762, 763, 764, 77, 771, 772, 773, 774, 775, 776, 778, 784, 785, 811, 812, 813, 821, 831, 841, 842, 843, 844, 845, 846, 848, 851, 871, 872, 873, 874, 881, 882, 883, 884, 885, 891, 892, 893, 894, 895, 896, 897, 898, 899, 98.

Note: All SITC codes are used from the research of (Wilmsmeier et al., 2006)