FINAL PROJECT – TI 184833

# ANALYSIS OF CONTAINER THROUGHPUT DETERMINANTS: A CASE STUDY ON INDONESIA'S FOUR MAJOR PORTS IN GLOBAL MARITIME TRADE

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# APPROVAL SHEET

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**FINAL PROJECT**

Submitted as a Requisite to Acquire a Bachelor Degree from
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**SURABAYA, AUGUST 2020**

# ANALYSIS OF CONTAINER THROUGHPUT DETERMINANTS: A CASE STUDY ON INDONESIA'S FOUR MAJOR PORTS IN GLOBAL MARITIME TRADE

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## ABSTRACT

As much as 80% of the global trade is entrusted to maritime logistics with 24% of it is shipped in containerized cargoes. Hence, ports become the main gateway in the overall door-to-door supply chain. The nature of maritime trade involves activities across borders and bilateral or even multilateral partnerships. Therefore, factors related to economy in large-scale—or also known as macroeconomics factors—may impose the port performance. The port performance can be measured through its container throughput. Therefore, aside from looking out for the external factors, port operators are still bound to maintain their logistics performance i.e. container throughput. With that being said, Indonesia as a maritime country should be able to leverage their maritime logistics potential. In order to shed a light on how the economic trends and logistics aspects affect the ports in Indonesia, this research attempts to model the relationship by using panel data regression method. Using the data from 29 ports from 26 countries in the period of 2009—2018, the study found that maritime logistics factors of connectivity indices (PLSCI and LSBCI) are influencing positively the container throughput, while the presence of multimodal facility shows otherwise. In the context of macroeconomic, gross domestic product (GDP) and bilateral trade intensity index (TII) indicates a positive association with container throughput which contradicts with the presence of free-trade agreements that affects negatively on the container throughput. Results also indicate that exchange rate volatility has no strong evidence to be associated with port container throughput. The exploration results from various interaction effects are also taken into account in respect to the four major ports in Indonesia—Tanjung Priok Port, Tanjung Perak Port, Belawan Port, and Makassar Port. The result can be used to alert the policy-makers or decision-makers regarding the strategies to increase maritime trade performance in terms of port container throughput.

**Keywords**: Maritime Logistics, Macroeconomics, Port Container Throughput, Panel Data Regression

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Surabaya, July 2020

Author

# TABLE OF CONTENT

APPROVAL SHEET ..... i

ABSTRACT ..... iii

ACKNOWLEDGEMENT ..... v

TABLE OF CONTENT ..... vii

TABLE OF FIGURES ..... xi

LIST OF TABLES ..... xiii

CHAPTER 1 INTRODUCTION ..... 1

1.1 Background ..... 1

1.2 Problem Identifications ..... 5

1.3 Objectives of Research ..... 6

1.4 Benefits of Research ..... 6

1.5 Scope of Research ..... 6

1.5.1 Limitations ..... 7

1.5.2 Assumptions ..... 7

1.6 Research Outline ..... 8

CHAPTER 2 LITERATURE REVIEW ..... 11

2.1 Maritime Logistics and Global Trade ..... 11

2.2 Port Industry and Their Role in Maritime Logistics ..... 12

2.3 Connectivity Indices ..... 15

2.4 Macroeconomics ..... 19

2.4.1 Gross Domestic Product ..... 20

2.4.2 Exchange Rate ..... 22

2.4.3 Bilateral Trade ..... 23

2.5 Econometrics ..... 24

2.6 Statistical Analysis ........ 25
2.6.1 Panel Data ........ 25
2.6.2 Panel Data Regression ........ 27
2.6.3 Assumption testing ........ 31
2.6.4 Model Testing ........ 33
2.7 Previous Researches ........ 34
CHAPTER 3 RESEARCH METHODOLOGY ........ 41
3.1 Flowchart of Methodology ........ 41
3.2 Methodology Description ........ 42
3.2.1 Research Hypotheses ........ 42
3.2.2 Data Collection ........ 42
3.2.3 Scenario Development with Panel Regression ........ 50
3.2.4 Approach Selection ........ 52
3.2.5 Numerical Test ........ 53
CHAPTER 4 DATA COLLECTION AND PROCESSING ........ 55
4.1 Data Collection ........ 55
4.1.1 Container Throughput ........ 55
4.1.2 Port Liner Shipping Connectivity Index (PLSCI) ........ 57
4.1.3 Liner Shipping Bilateral Connectivity Index (LSBCI) ........ 58
4.1.4 Multimodal Facility ........ 61
4.1.5 Gross Domestic Product (GDP) ........ 63
4.1.6 Exchange Rate Volatility ........ 65
4.1.7 Bilateral Trade Intensity Index (TII) ........ 69
4.1.8 Free-Trade Agreements ........ 74
4.2 Panel Regression Modelling ........ 78
4.2.1 Scenario 1: Port as Individuals ........ 78

4.2.2 Scenario 2: Port as Pairs ........ 81
4.3 Model Selection ........ 83
4.3.1 Scenario 1 ........ 84
4.3.2 Scenario 2 ........ 84
4.4 Assumption Testing ........ 85
4.4.1 Multicollinearity Test ........ 85
4.4.2 Autocorrelation Test ........ 89
4.4.3 Heteroscedasticity Test ........ 90
4.5 Generalized Least Squares (GLS) with Weighted Cross-Sections Estimation: Responding to Autocorrelation and Heteroscedasticity ........ 91
4.5.1 Scenario 1 ........ 92
4.5.2 Scenario 2 ........ 94
4.6 Model Testing ........ 96
4.6.1 Partial Significance Test (t-test) ........ 96
4.6.2 Simultaneous Significance Test (F-test) ........ 98
4.6.3 Coefficient Determination ($R^2$) Test ........ 99
CHAPTER 5 ANALYSIS AND INTERPRETATION ........ 101
5.1 Technical Analysis on Panel Regression Estimation ........ 101
5.2 Hypothesis Analysis: Maritime Logistics Factor ........ 106
5.3 Hypothesis Analysis: Macroeconomics Factor ........ 110
5.4 Hypothesis Analysis: Fixed Effects ........ 113
5.5 Analysis on Interaction Effects of Indonesia's Four Major Ports ........ 119
5.5.1 Indonesian Ports on Predetermined Clusters ........ 119
5.5.2 Potential Port Partners ........ 124
CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS ........ 129
6.1 Conclusions ........ 129

6.2 Recommendations .................................................................................. 131
REFERENCES......................................................................................... 133
ATTACHMENTS ..................................................................................... 141
AUTHOR'S BIOGRAPHY ................................................................... 151

# TABLE OF FIGURES

Figure 1.1 Seaborne and container trade growth to GDP growth .......................... 2
Figure 1.2 Container throughput and GDP growth of four major ports in South-East Asia ........................................................................................................ 3
Figure 2.1 Container port layout ............................................................................ 12
Figure 2.2 Top 10 busiest port worldwide ............................................................ 14
Figure 2.3 Container throughput of major Indonesia's ports ................................ 14
Figure 2.4 Top 20 ports PLSCI and throughput by country's nominal GDP 2018 17
Figure 2.5 Global containerized trade by route ..................................................... 18
Figure 2.6 Indonesia's GDP growth and its container throughput 2009-2018 ...... 21
Figure 2.7 Approach selection tests for panel data regression .............................. 31
Figure 3.1 Flowchart of research methodology .................................................... 41
Figure 5.1 Container throughput actual vs forecast with the 5-year data model (2014 – 2018) ............................................................................................................ 105
Figure 5.2 Top 10 PLSCI from Selected Samples .............................................. 107
Figure 5.3 PLSCI Score of Indonesian Ports ...................................................... 107
Figure 5.4 The Presence of Multimodal Facility Over The Year in Selected Ports ........................................................................................................................ 109
Figure 5.5 Container Throughput in Four Major Ports – Indonesia (2009—2018) ........................................................................................................................ 115
Figure 5.6 Container Throughput by Cluster (2009—2018) .............................. 116

# LIST OF TABLES

Table 2.1 Components of connectivity indices by UNCTAD .............................. 16
Table 2.2 Previous researches related to this research......................................... 37
Table 2.3 Research position .................................................................................... 39
Table 3.1 List of hypotheses to be tested in this research..................................... 42
Table 3.2 List of variables used for the research ................................................. 44
Table 3.3 List of sample selected.......................................................................... 46
Table 3.4 Data requirements ................................................................................. 48
Table 4.1 Container Throughput of 29 Ports Sample from 2009-2018 (in TEUs) 56
Table 4.2 Port Liner Shipping Connectivity Index of 29 Ports Sample from 2009-2018.............................................................................................................. 57
Table 4.3 Liner Shipping Bilateral Connectivity Index of 26 Countries Sample from 2009-2018 ......................................................................................................... 59
Table 4.4 Multimodal Facility of 29 Ports from 2009-2018................................. 62
Table 4.5 Gross Domestic Product of 29 Ports Sample 2009-2018 (in million dollars)................................................................................................................ 63
Table 4.6 Example of Exchange Rate Data from 2009-2018 ............................... 65
Table 4.7 Exchange Rate Volatility Data of 26 Countries Sample from 2009-2018 ....................................................................................................................... 67
Table 4.8 Export Data of 26 Countries from 2009-2018 (in thousand dollars).... 70
Table 4.9 Import Data of 26 Countries from 2009-2018 (in thousand dollars).... 71
Table 4.10 Bilateral Trade Intensity Index of 26 Countries from 2009-2018 ...... 73
Table 4.11 Free-Trade Agreements Dummy of 26 Countries Sample from 2009-2018.............................................................................................................. 75
Table 4.12 Scenario 1: Fixed Effects Model (FEM) Result ................................. 78
Table 4.13 Scenario 1: Random Effects Model (REM) Result............................. 80
Table 4.14 Scenario 2: Fixed Effects Model (FEM) Result ................................. 82
Table 4.15 Scenario 2: Random Effects Model (REM) Result............................. 82
Table 4.16 Scenario 1: Hausman Test ................................................................. 84
Table 4.17 Scenario 2: Hausman Test ................................................................. 85
Table 4.18 Scenario 1: Correlation Matrix and VIF Score ................................... 86

Table 4.19 Scenario 2: Correlation Matrix and VIF Score .................................. 88
Table 4.20 Scenario 1: Wooldridge Autocorrelation Test ................................... 90
Table 4.21 Scenario 2: Wooldridge Autocorrelation Test ................................... 90
Table 4.22 Scenario 1: Heteroscedasticity Test .................................................. 91
Table 4.23 Scenario 2: Heteroscedasticity Test .................................................. 91
Table 4.24 Scenario 1: Panel EGLS Method Summary....................................... 92
Table 4.25 Scenario 1: Comparison of FEM, REM, and Weighted Cross-Section EGLS ................................................................................................................ 93
Table 4.26 Scenario 2: Panel EGLS Method Summary....................................... 94
Table 4.27 Scenario 2: Comparison of FEM, REM, and Weighted Cross-Section EGLS ................................................................................................................ 95
Table 4.28 Scenario 1: t-Statistic Summary......................................................... 97
Table 4.29 Scenario 2: t-Statistic Summary......................................................... 97
Table 4.30 Scenario 1: F-Statistic Summary........................................................ 98
Table 4.31 Scenario 2: F-Statistic Summary........................................................ 99
Table 4.32 Scenario 1: R-squared Value Summary ............................................. 99
Table 4.33 Scenario 2: R-squared Value Summary ........................................... 100
Table 5.1 Scenario 1: Comparison between model with 10-year period vs 5-year period................................................................................................................ 104
Table 5.2 Top LSBCI Worldwide (left), Indonesia (right) ................................ 108
Table 5.3 Summary of Port Effects and Cluster Effects from Scenario 1 and Scenario 2 ......................................................................................................... 117
Table 5.4 Summary of Hypotheses Analysis ..................................................... 119
Table 5.5 Cluster Interaction Effects: Four Major Ports of Indonesia on Asia, Europe, Northern America, and Oceania .......................................................... 122
Table 5.6 Port Partner Interaction Effects: Tanjung Priok and Tanjung Perak on Port Partners........................................................................................................... 126
Table 5.7 Port Partner Interaction Effects: Belawan and Makassar on Port Partners ........................................................................................................................ 127

# CHAPTER 1
# INTRODUCTION

This chapter explains about the research background, problem identifications, research objectives, research benefits, research limitations and assumptions, and research outline.

## 1.1 Background

The current state of global trade is a result of tremendous increase in volume and investment along with a rapid development of transportation and information technologies. Having 70% of Earth's surface covered by water, maritime transportation accounts for over 80% of global trade by volume and 70% of global trade by value (UNCTAD - United Nations Conference on Trade and Development, 2019). With that statistics in mind, Indonesia as one of the largest archipelagic country in the world relies strongly to its maritime potential. As the majority of Indonesia's territory is sea, it makes sense how maritime transportation becomes the backbone of international trade and inter-island shipping.

In maritime logistics, commodities being shipped are transported in the form of bulk cargo, containerized, or other type of cargo. UNCTAD also stated that, in 2018, containerized cargo contributes to 23.5% volume of world's seaborne trade and remains increasing each year. Even though its contribution to the global trade is not as large as bulk cargo, containerized cargoes account for more than a two-third of world's seaborne trade in terms of value. Container shipping covers a variety of trades, almost all manufactured items that can be loaded on pallet or floor-loaded can be containerized (e.g. daily items, foods, electronics, clothing, chemicals, etc.). Reflecting to the compatibilities and conveniences in container shipping, it strengthens the role of container shipping in fulfilling needs. In order to distribute the goods, ports become the main gateway in the overall door-to-door supply chain especially in global trade. Moreover, ports and shipping industry in general is indicated by volume and growth (Murnane, 2017).

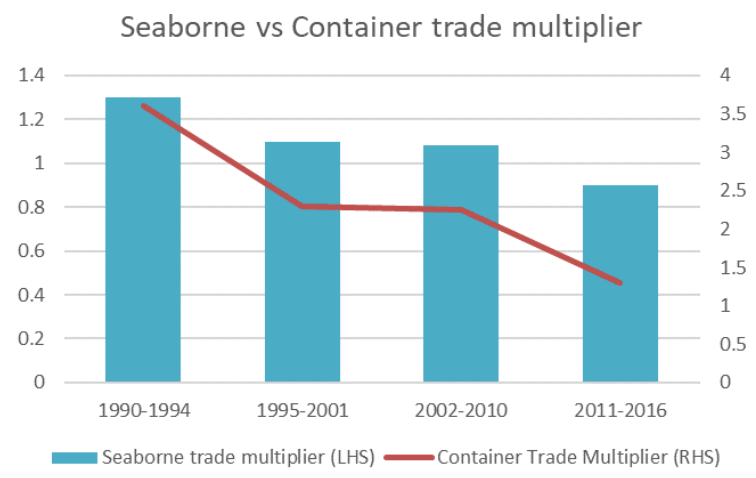


Figure 1.1 Seaborne and container trade growth to GDP growth

Source: Clarksons Research (2016)

The figure above shows the decline of seaborne trade multiplier and container trade multiplier over the years. These multipliers are the ratio between the total volume of seaborne (container) growth and GDP growth. It is an essential ratio that is often used in port traffic or throughput forecasting since it tends to be associated with economic growth prospect. The current container trade-to-GDP ratio is seen as in an unhealthier level ever since the global financial crisis in 2008. As the International Monetary Fund announced, the global economic growth last year is just at 3%. If back then in 1990s, a GDP growth of 3% could have meant 10.5% or greater container trade growth, in 2011-2016, the case would be at just 4% growth. It illustrates that GDP growth has less of an impact nowadays. Even last year, the number has fallen again to 0.3 due to protectionism and global slowdown (Lloyd's List, 2019).

Therefore, macroeconomics is an inseparable factor in maritime trades. Port as the main gateway responsible in maritime logistics should understand which factors and trends that should be addressed. Without a firm understanding of what are the aspects that should be examined and how the relationship goes, governments, local authorities, and port operators can miss the benefits derived in terms of logistics (Haralambides, 2019).

Now, the remaining question is how Indonesia with its maritime trade potential can maximize the opportunity of leading maritime logistics and benefit from it especially from ports' perspective as the integral part. Hence, the performance of a port should be well-monitored and evaluated. Port performance has been measured through various indicators and one of them is by measuring the port throughput. It becomes a standard measure of port productivity (Bureau of Transportation Statistics, 2017). When the performance of the port--indicated by its throughput--is unsatisfactory, logistics costs and reliability of supply chains become compromised. Take it to a more macro level, poor logistics facilitation brings disadvantages on country's competitive advantage (Arvis et al., 2007).

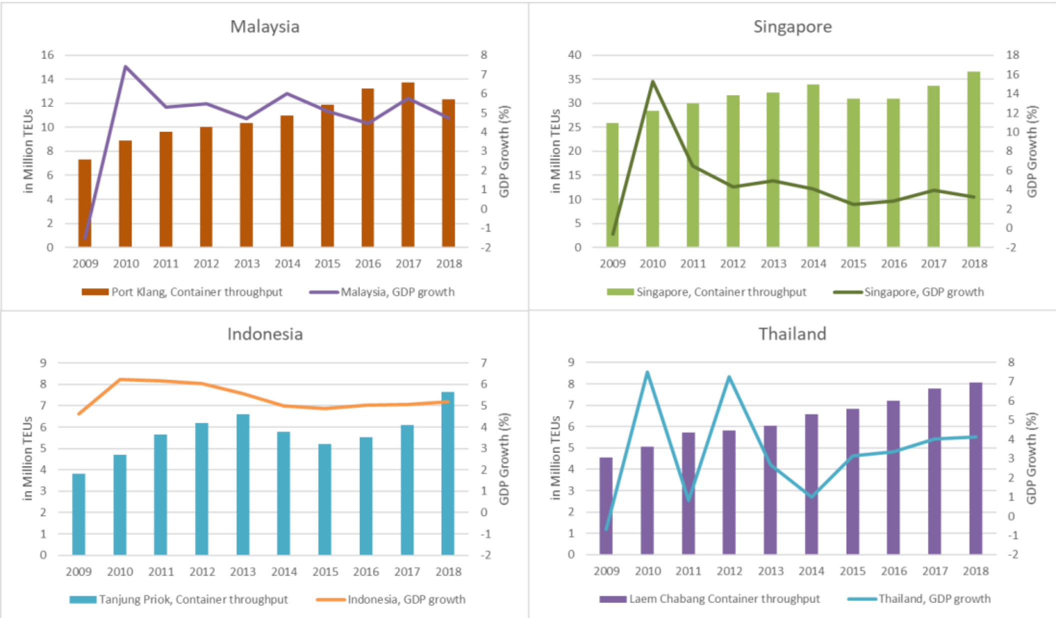


Figure 1.2 Container throughput and GDP growth of four major ports in South-East Asia

Source: UNCTAD Stat (2019); IAPH - International Association of Ports and Harbors (2013); World Shipping Council (2019)

From the graph above, the container throughput is presented against the GDP growth of the country. It can be seen even Indonesia's top port hub still has a long way to go to even to its closest neighbor, Singapore. As been mentioned previously, the GDP growth and container throughput (and global trade in general) have a meaningful relationship. There is a similar pattern that can be seen especially in Indonesia and Singapore graph. Then the next question arises, whether it is still relevant and how come the other country shows otherwise. According to Maritime and Port Authority of Singapore (MPA), the secret behind its superior port relies on ensuring the 3Cs of Connectivity, Capacity, and Competitiveness (MPA, 2019). With links to more than 600 ports across 120 countries worldwide—making it one of the densest and most connected port in the world, Singapore sets a high bar of connectivity definition in ports. They utilize their coastal location with the right strategy. Hence, Indonesia should not waste such potentials of the geographical location and catch up the factors being missed.

United Nations Conference on Trade and Development (UNCTAD) has provided a measurement called Liner Shipping Connectivity Index (LSCI) that can capture a country's level of integration into the existing global liner shipping network. These indices are available in country-basis, bilateral-basis (also known as LSBCI or Liner Shipping Bilateral Connectivity Index), and port-basis (also known as PLSCI or Port Liner Shipping Connectivity Index). It is proven that better connectivity and infrastructure leads to higher volume of international trade (Fugazza & Hoffmann, 2017).

Another maritime logistics factors that can further complement the connectivity is the availability of multimodal connection in a port. Factors such as shipping companies' alliances, stevedoring companies, intermodal transportation are just as important to be accounted if talking about container throughput (Janssens et al., 2003). In theory, a long distance distribution overseas i.e. maritime international trade is carried out by at least two modes of transportation since it needs to cross the land and continued by either a ship or an aircraft. The most common multimode for logistics is ships and railways but then again it depends on the cargo characteristics. According to the Pujawan & Mahendrawathi (2017), value-to-weight ratio of a commodity can base a transportation mode decision especially for long distance. As the ratio gets higher (low volume high value), the appropriate decision will fall under air cargoes. On the contrary, the low ratio (large volume low value), is best attributed with ocean freight vessels or railways. Therefore, it is understandable why ports should facilitate the multimodal connection to attract more shippers and carriers.

The empirical research of maritime logistics and global trade has been extensively growing within the last two decades with port efficiency measurements and indicators become the frontline of research area in maritime logistics and economics. Some study still lay the groundwork on country-level instead of specifying to the port-level (Yang, Zhao, & Yanagita, 2016; Isdiana & Aminata, 2019). Yet, a comprehensive study for specifically Indonesia case remains scarce. As far to the author's knowledge, no study to date has investigated the position and potentials of ports in Indonesia to the maritime logistics and global trade context. For Indonesia context, the closest one would either analyze on a specific one port or a few ports only (Haris, 2019; Aqmarina & Achjar, 2017), or it was done in the context of other ports in a case study of different regions (Vitsounis, Paflioti, & Tsamourgelis, 2014; Liu & Park, 2011; Cho, 2014).

Hence this research is an attempt to fill the gap by formulating a model that is able to explain the determinants of port container throughput in Indonesia in the context of maritime logistics and macroeconomics. Furthermore, the study will analyze the behavior and potential of several global port clusters related to the four major ports in Indonesia: Tanjung Priok Port, Tanjung Perak Port, Belawan Port, and Makassar Port. Using a 10-years data from 2009 to 2018, further analysis is done through panel data regression method with determinants from maritime logistics factors and macroeconomic factors. The data is obtained from various sources elaborated in Subchapter 3.2. The result can be used to alert the policy-makers or decision-makers regarding the strategies to increase maritime trade performance in terms of port container throughput.

## 1.2 Problem Identifications

The problem that will be investigated in this research is how the container throughput changes in Indonesia's ports, in response to maritime logistics factors (connectivity indices, multimodal facility effect) and macroeconomic factors (gross domestic product or GDP, bilateral trade intensity, exchange rates, free trade agreements).

## 1.3 Objectives of Research

The objectives of this research are as follows.

1. To develop a model that can describe the relation between maritime logistics and macroeconomics factors towards the port container throughput.
2. To understand how the interdependency between maritime logistics and macroeconomics towards the port container throughput.
3. To identify the critical variable—among the maritime logistics and macroeconomics factors—on the port container throughput.
4. To understand how each predetermined cluster influences the container throughput in Indonesia's four major ports.
5. To identify potential port partners for each Indonesia's four major ports.

## 1.4 Benefits of Research

The benefits from this research are as follows.

1. Provide an illustration of maritime logistics and macroeconomics implication on port productivity in Indonesia.
2. Provide insights to decision-maker and policy-maker on how to set strategies to increase maritime trade performance in terms of port container throughput.
3. Provide a model that can be utilized by port operators to measure risk in port operations context.
4. As the reference for further studies in maritime logistics and trade analysis in Indonesia.

## 1.5 Scope of Research

The scope of research is the boundaries that will help in conducting this research. It consists of two aspects: limitations and assumptions.

### 1.5.1 Limitations

This subchapter contains key aspects that narrow the scope of this research and focusing the research on the determined problem. The limitations of this research are:

1. The object of study is focused on four major ports in Indonesia as the representative of each region of state-owned port operators (Pelabuhan Indonesia or Pelindo). There are Belawan Port (PT Pelindo I), Tanjung Priok Port (PT Pelindo II), Tanjung Perak Port (PT Pelindo III), and Makassar Port (PT Pelindo IV).
2. The overseas ports for comparison are limited from countries with historical export import activity with Indonesia.
3. The 25 countries sampled are based on top 35 countries with the highest container throughput intersected with the highest exporters to and importers of Indonesia.
4. The data is in the form of annual aggregate and for the period of study 2009 to 2018.

### 1.5.2 Assumptions

This subchapter contains several elements that are omitted and other variables that are used in this research. The assumptions of this research are:

1. The connectivity indices used are assumed to be adequate enough as a proxy for port performance parameters or internal management factors of ports.
2. The port performance parameters or internal management factors of ports are represented by the components of connectivity indices used. The components are broken down in Chapter 2.
3. The exchange rate referred is assumed to be the one from International Monetary Fund (IMF) complemented with data from independent database (FXTOP).
4. The effect of binary dummy variable that depends on more specific time period than annual (e.g. kickoff date of free trade agreements) is neglected.

5. Hinterland gross domestic product (GDP) of Indonesia's ports is derived from total gross regional domestic product (GRDP) of provinces under the related Pelindo's working regions (*wilayah kerja*).
6. The container throughput value in the dependent variable is a cumulative of loading and unloading of both domestics and international trades.
7. The effect of trade barriers is neglected.
8. The effect of transshipment or transit is neglected.
9. The estimation result from the second processing of regression modelling which uses Generalized Least Squares (GLS) is assumed to be BLUE (Best Linear Unbiased Estimator).

## 1.6 Research Outline

This research is outlined in a way that will ease the presentation and for readers to understand. The outline of the research is explained below.

**CHAPTER 1 INTRODUCTION**

This chapter explains about the research background, problem identifications, research objectives, research benefits, research limitations and assumptions, and research outline.

**CHAPTER 2 LITERATURE REVIEW**

This chapter presents relevant theories that will be used in this research. This chapter explains about maritime logistics, port industry, connectivity indices, macroeconomics factor, econometrics, panel regression method, and previous studies relevant to the topic of this research.

**CHAPTER 3 RESEARCH METHODOLOGY**

In this chapter, the steps or activities involved in conducting this research will be explained. The methodology will be complemented with flowchart and description of the steps. The steps consist of data collecting, regression modelling, result analysis and interpretation, as well as conclusions and suggestions.

**CHAPTER 4 DATA COLLECTION AND PROCESSING**

In this chapter, the data collected will be processed to solve the problem. The suspected determinants of container throughput are processed with regression modelling so the relation between elements can be analyzed further. There will be two main models tested to see the impact of ports and clusters created in the model.

**CHAPTER 5 ANALYSIS AND INTERPRETATION**

This chapter covers the interpretation from the result of model running. The in-depth analysis of the result from the previous chapter will also be explained here. The analysis covers from logistics and supply chain context as well as macroeconomic context.

**CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS**

This chapter contains conclusions of this research referring to the objectives stated in the beginning. The recommendations for future researches will also be included in this chapter.

# CHAPTER 2
# LITERATURE REVIEW

This chapter presents relevant theories that will be used in this research. This chapter explains about maritime logistics, port industry, connectivity indices, macroeconomics factor, econometrics, panel regression method, and previous studies relevant to the topic of this research.

## 2.1 Maritime Logistics and Global Trade

Maritime logistics essentially is a part of logistics with focus on the maritime area or sea transportations. It is primary associated with transporting materials or finished goods on a global scale but not disregarding its role on domestic inter-island means. Not to be confused with the term *maritime transportation* that also include passengers' movement. Council of Supply Chain Management Professionals (2010) defines logistics as the part of supply chain management that plans, implements, and controls the movement and storage of goods in the most effective and efficiently from the point of origin to the point of consumption in response to meet customers' demand. Therefore, maritime logistics can be defined as "the process of planning, implementing and managing the movement of goods and information which is involved in ocean carriage" (Lee et al., 2015). It differs with maritime transportation in the sense of how maritime logistics also highlights the importance of effective logistics flow as one integrated system. While maritime transportation involves activities such as contracting, shipping, sea voyage, moving cargo, and loading/unloading, maritime logistics over far more services such as, stripping/stuffing, storage, warehousing, inventory management, offering a distribution center, quality control, testing, assembly, packaging, repacking, repairing, inland connection, and reuse (World Bank, 2006).

Maritime logistics has three key functions: shipping, port/terminal operating, and freight forwarding. Shipping's main function is moving cargoes between ports. Port operators do the shipping reception, loading/unloading cargoes, stevedoring, and connecting to inland transportation. While freight forwarders act more as a third intermediate party that arrange vessel booking and document preparation on behalf of shippers (Lee et al., 2015). Therefore, to achieve an effective and efficient maritime logistics, the three have to do their part properly and increase the integration between parties.

## 2.2 Port Industry and Their Role in Maritime Logistics

Seaports act as the backbone of maritime businesses; be it the logistics of goods and the transportation of people. Inter-island and international trade of archipelagic country like Indonesia relies on the maritime transportation modes since the commodities are transported port-to-port through ships and vessels. Ports hold an important role to integrate the logistics, trade, and supply channel (Bichou & Gray, 2004). Ports work in bi-directional logistics systems in which they facilitate as the meeting point between the sea-leg and land-leg distributions (Song & Panayides, 2008). The diagram below illustrates the general layout in port.

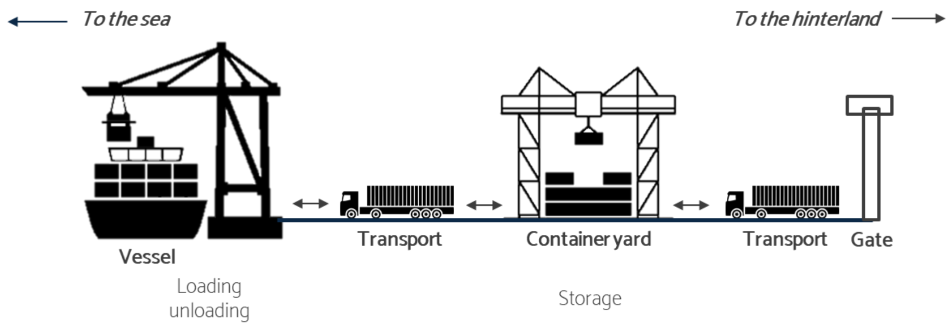


Figure 2.1 Container port layout

Source: adapted from Phan & Kim (2015)

Take example of the container port depicted in the diagram. The main function of a container port is to serve the needs of moving cargoes from and to the vessel. Hence, the efficiency of this activity is a crucial indicator as ports' productivity is measured by its throughput. Port throughput by definition reflects on "the amount of cargo or number of vessels the port handles over time" (Bureau of Transportation Statistics, 2017). US Department of Defense put port throughput definition in more general and comprehensive measure by accounting quantity of passengers as a part of port throughput. The full definition they provide is "the quantity of cargo and passengers passing through a port on a daily basis, from their arrival at the port to their loading onto a ship, or from their discharge from a ship to the exit (clearance) from the port complex" (US Department of Defense, 2005).

The common throughput consists of three types: cargo tonnage, vessel calls, and container TEU. Cargo tonnage is commonly used to refer bulk cargo but it may refer to the weight of the contents of shipping containers. Vessel calls refer to the number of visitation by vessels to a port with the unit measurement of number of vessel calls or gross tonnage. The famous one, TEU (Twenty-foot Equivalent Unit), is commonly used for containerized cargoes. Standard ISO unit for container is a box with external dimensions: 20 feet long, 8 feet wide, and 8.6 feet high. Some reports that use 'TEUs' eliminate the double-counting of the box being lifted, yet it still accounts the empty container as well. Some also may use 'loaded units handled' in which double-counting and empty container are included (Wijnolst & Wergeland, 2008).

Port throughput is the main essential and direct variable for measuring the strength of port competitiveness (Liu & Park, 2011). It could be affected by many variables beyond physical capacity of the port. For example, demand for cargo handled by port from international and domestic, competition with other ports, arrangements with carriers, and changes in distant facilities. Economic level of a country where the port located also has a relationship with the port throughput. Notice how the top 10 busiest ports as depicted in the figure below are dominated by one specific country, China, which is a leading economy country with high industrial production and trade. Enormous power in industrial production increases the traffic of trade which eventually lead to the increase in the volume handled by maritime transportation (UNCTAD, 2019).

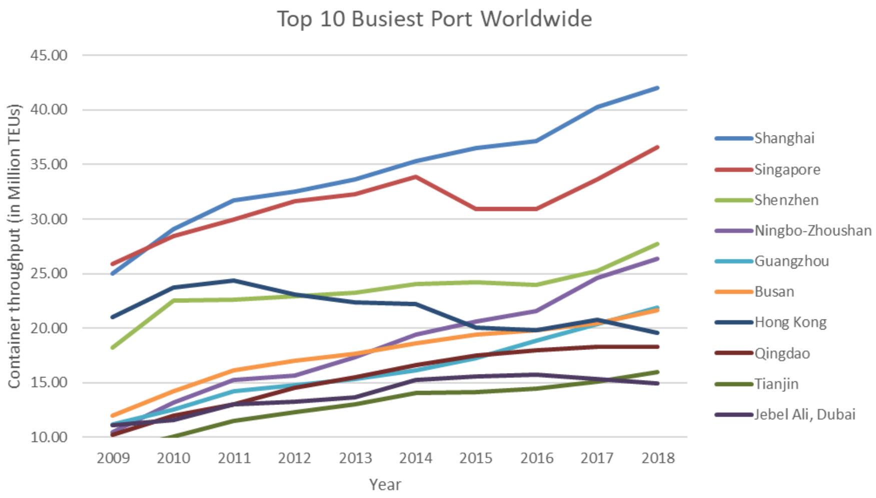


Figure 2.2 Top 10 busiest port worldwide

Source: World Shipping Council, (2019)

For the case of Indonesia's port, they are still far from the top 10. Take a look at the diagram below. The total container throughput in Indonesia in 2018 has reached 12.8 million TEUs which is similar to the throughput of the top port in Malaysia, Port Klang. Almost 90% of the nation's TEUs is a result from only the three largest ports in Indonesia: Tanjung Priok Port, Tanjung Perak Port, and Belawan Port.

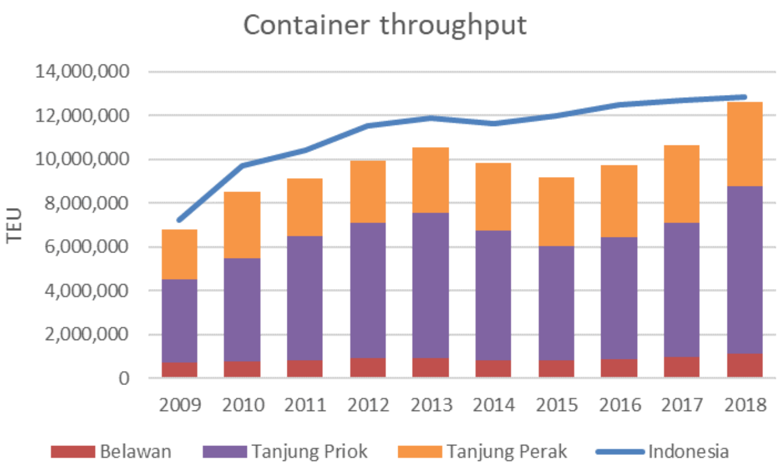


Figure 2.3 Container throughput of major Indonesia's ports

Source: IAPH (2013), Lloyd's List (2019), Haris (2019)

Port operations in Indonesia are largely handled through state-owned enterprises under Ministry of Transportation namely Pelabuhan Indonesia (Pelindo) I until IV. Each one of them has their own working area (*wilayah kerja*). It is divided based on the location of the service area. The western part of Indonesia is managed commercially by Pelindo I and II. In this region, there are two major ports: Tanjung Priok Port (under Pelindo II) and Belawan Port (under Pelindo I). The eastern part of Indonesia also has two main ports and serve as the largest ones in the region which are Tanjung Perak Port (under Pelindo III) and Makassar Port (under Pelindo IV).

The government of Indonesia already planned and set a constitution that instructs on the development of ports, so the growth enlargement could be seen in effect sooner. Shipping Law No. 17/2008 in lieu of Law No. 21/1992, covers various sea-related matters such as shipping, navigation, environmental protection, ship crew welfare, maritime accidents, human resource developments, public involvement, set up of coastal guard, and etc. Law No.17/2008 mandated that Indonesia should build an efficient, competitive, and responsive port system (Pelindo II, 2011). This law also allows privatization of port businesses to increase investment and competitiveness. The latest master plan regarding the development of new international hub project also took a start in 2018 (Direktorat Jenderal Perhubungan Laut, 2019).

### 2.3 Connectivity Indices

Connectivity is an integral part in maritime logistics. In the context of port integration with supply chain, there are some critical variables to be considered such as, technology, value added services, relationship with clients and liner operators, facilitation of intermodal transport, and channel integration practices (Song & Panayides, 2008). It shows how connectivity hold a strong relation with ports in maritime logistics. United Nations Conference on Trade and Development (UNCTAD) has provided a measurement called Liner Shipping Connectivity Index (LSCI) that can capture a country’s level of integration into the existing global liner shipping network. These indices are available in country-basis, bilateral-basis (also known as LSBCI or Liner Shipping Bilateral Connectivity Index), and port-basis (also known as PLSCI or Port Liner Shipping Connectivity Index). These connectivity indices are a proxy for the accessibility to global trade. The higher the level, the easier it is for a country or a port to access the global maritime freight transport system. It also a measure of competitiveness and trade facilitation.

The first index is LSCI which reflects a country's position in the global liner shipping networks. A more specific one is Port LSCI (PLSCI) which reflects a port position in the global liner shipping network. While for a bilateral context, there is a Liner Shipping Bilateral Connectivity Index (LSBCI) which reflects a country pair's integration level in the global liner shipping network. The higher the value indicates better connectivity. These three have similar but different underlying components that build the index. For LSCI and PLSI, the components are the same but differ in the level of component examined: one is country-based and one is port-based. The components of each index is provided in the following table.

Table 2.1 Components of connectivity indices by UNCTAD

| No | LSCI | PLSCI | LSBCI |
|---|---|---|---|
| 1 | The weekly number of scheduled ship calls | | The number of transshipments required to get from country A to country B |
| 2 | Total deployed capacity offered | | The number of direct connections common to both country A and B |
| 3 | The number of regular liner shipping services from and to the port/country | | The number of common connections by country pair with one transshipment |
| 4 | The number of liner shipping companies that provide services from and to the port/country | | The level of competition on services that connect country A to country B |
| 5 | The largest average vessel size | | The largest vessel size on the weakest route connecting country A to country B |
| 6 | The number of other ports/countries to the port/country through direct connection | | |

Source: UNCTAD Stat

According to UNCTAD Stat on PLSCI, Indonesia's ports in 2018 have considerably low score in PLSCI compared to other neighboring country such as Singapore, Malaysia, and Thailand. As Tanjung Priok Port get as closest as to top 70 worldwide. Port Klang, Malaysia, is now the second-leading port in ASEAN behind Singapore who reaches the second-best connected port worldwide. Consider the figure below in which the top 20 ports worldwide in terms of PLSCI score is plotted against its container throughput and the size of their economies (indicated by GDP). Countries with small GDP could compete in terms of container throughput once they have the connectivity. According to Maritime and Port Authority of Singapore (MPA), the secret behind its superior port relies on ensuring the 3Cs of Connectivity, Capacity, and Competitiveness (MPA, 2019). With links to more than 600 ports across 120 countries worldwide—making it one of the densest and most connected port in the world. The extensive connectivity is supported with profound implementation of advance infrastructures and technologies, and comprehensive policy. By doing so, any port should be able to reach the same level as Singapore.

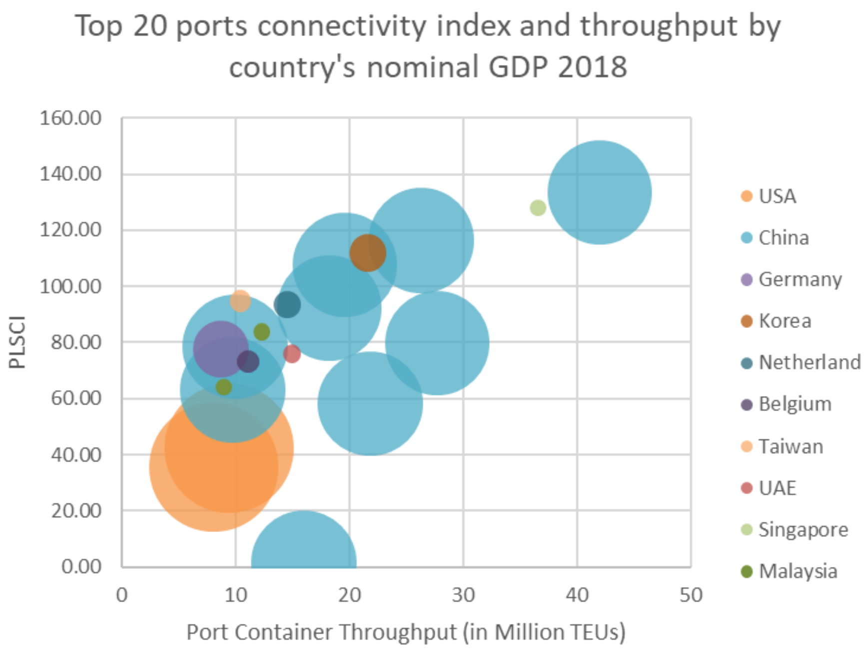


Figure 2.4 Top 20 ports PLSCI and throughput by country's nominal GDP 2018

Source: World Shipping Council (2019) and UNCTAD (2019)

In addition to connectivity indices, ports depend on multimodal connections to facilitate the flow from vessels to land transportation modes. Typically, ports are connected by one or more railroads as well as highways to support the hinterland transportation. Container ports could have on-dock connections within the port areas off-dock connections nearby. Factors such as shipping companies' alliances, stevedoring companies, intermodal transportation are just as important to be accounted if talking about container throughput (Janssens et al., 2003).

In tandem with the countries' economic growth, development, and trade requirements, ports are forced to refine themselves to cope with the changes. The developments are not limited to infrastructural and technological advancement, but also structural reformation. The more ports are developed, the more attractive it becomes for shipping lines to build direct connection instead of transiting in various ports which consequently lengthen the duration. Thus, port efficiency and productivity should be evaluated regularly. The trend towards smaller ships and direct calls will also be facilitated by the growth of trade in intra-Asia, which now represents more than a half of international trade. Thus it consequently ensues the development of Asian ports and fleets to serve this trade.

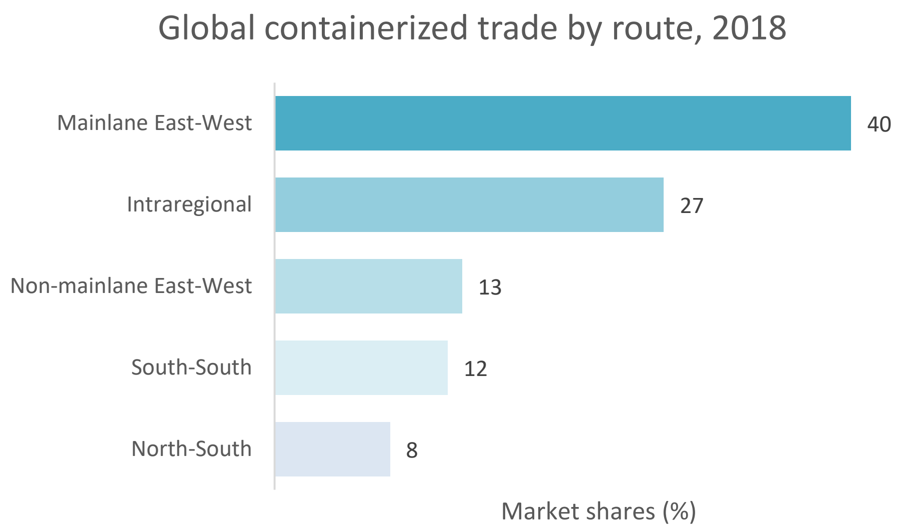


Figure 2.5 Global containerized trade by route
Source: UNCTAD, 2019

The figure above shows the market share of containerized trade by the trade lane. The majority of the world's containerized trade is at its densest on Mainlane East-West route (East Asia—Europe, Trans Pacific, Transatlantic). Intraregional alone is dominated by intra-Asian route. For the case of connectivity index, the highest LSBCI values are obtained for intra-regional routes, notably intra-Europe and intra-Asia. Some of the Asia-Europe connections are also among the top 20 (Fugazza & Hoffmann, 2017).

Distance is viewed as a classic representative of connectivity to be used as a determinant in prior studies related to maritime trade. However, distance does not reflect the relation and the position of a port in the transport network (Frazila & Zukhruf, 2015). Asturias and Petty (2012) concluded that distance turns statistically insignificant in a trade model when two ports are connected by a direct connection or direct call. It is hypothesized that a connectivity index such as Port Liner Shipping Connectivity Index (PLSCI) can explain the port container throughput better since it is a more advanced version than LSCI as it counts the parameters on port level rather than country level (UNCTAD, n.d.). According to the author knowledge, the PLSCI itself has not been studied under the determinant analysis nor the maritime trade domain. Previous study related to maritime trade, tested the index of LSBCI as one of the determinants and found out the positive and significant relationship between the LSBCI and the volume of containerized exports (Fugazza & Hoffmann, 2017).

## 2.4 Macroeconomics

The concept of macroeconomics is included in this research as the external factor affecting the port container throughput. Macroeconomics itself is a branch of the economy as a whole which includes growth in incomes, price changes, and unemployment rates (Mankiw, 2016). These three concerns are the most used definition of macroeconomics analysis. Dornbusch and Fisher (1981) include the total output of goods and services, the balance of payments, and exchange rates as the major concern of macroeconomics as cited from their book “Macroeconomics”. Thus, macroeconomic analysis tries to explain economic events through models and to provide the basis of policies to improve economic performance (Mankiw, 2016). The model itself is a simplification of the reality used to investigate the relationship between dependent variables and its explanatory variables. Different cases will require different models. While macroeconomics trying to explain the aggregate markets (Rittenberg & Tregarthen, 2009), microeconomics on the other hand studies how firms or businesses and individuals interact and make decisions. All macroeconomic models should be consistently grounded on microeconomic foundations even though the presence is only implicit; because macroeconomic events lie on many microeconomic interactions (Mankiw, 2016).

In order to do macroeconomic analysis, there are three common statistics and measurements used: GDP, CPI, and unemployment rate. The GDP (Gross Domestic Product) measures the value of economic activity. The CPI (Consumer Price Index) tells about the price level. The unemployment rate monitors the labor market by measuring the percentage of workers who are unemployed. However, this research uses GDP and the extended statistics in terms of exchange rates volatility, and Trade Intensity Index (TII).

### 2.4.1 Gross Domestic Product

Gross Domestic Product or GDP is the nation's total income and the total expenditure on its output of goods and services. Gross domestic product (GDP) is "the market value of all final goods and services produced within an economy in a given period of time" (Mankiw, 2016). There are two types of GDP: real GDP and nominal GDP. Real GDP or *PDB harga konstan* is measured using a constant set of prices. While nominal (current) GDP or *PDB harga berlaku* is measured using prices applied in the market without any deflator. Thus, real GDP provides a better measure of economic well-being than nominal GDP does (Mankiw, 2016).

According to Badan Pusat Statistik, the function of GDP can be described as in the following list.

1. Nominal GDP reflects the capability of economic resources produced by a country. High value of GDP shows high economic resources and vice versa.
2. Real GDP can be used to reflect the economic growth in general or per industry sector with year on year basis.
3. Nominal GDP also reflects on the utilization of goods and services for consumption purpose, investment, or trade with foreign countries.

4. Real GDP is useful to measure the growth of consumption, investment, and international trend.

Thus, in conclusion, real GDP is more useful due to its nature that able to explain growth better than nominal GDP. According to Ward (2017), Indonesia spends 26% of its GDP on logistics, and it is one of the highest rates of spending on logistics per capita in the world. Meanwhile, major commodity price gaps between provinces in Indonesia and so is major logistics inefficiencies inhibit economic development and connectivity. Likewise, the neighbor country, Thailand, which is considered has better connectivity and such still spends almost 20% of its GDP on logistics too (Logistics Management, 2017).

GDP as economy indicator shows that it influences the container throughput since the productivity of the area is reflected through the value of it. Besides study that proves GDP growth has supportive relation to port throughput (Vanoutrive, 2010), it is also commonly used as a variable for forecasting port throughput volume (BITRE, 2002; Van Dorsser et al., 2011; De Langen et al., 2012). GDP growth and container throughput in Indonesia itself can be seen in the following figure.

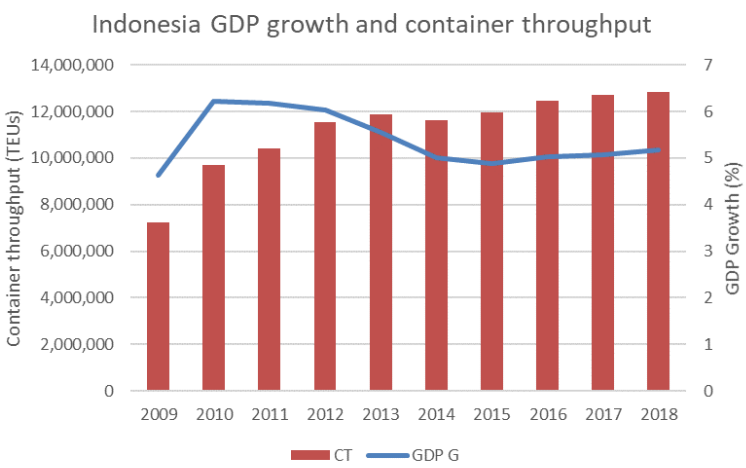


Figure 2.6 Indonesia's GDP growth and its container throughput 2009-2018

Source: UNCTAD Stat (2019)

Containerized cargo and GDP has been extensively studied and approved by academics (Liu & Park, 2011; Ducruet, 2009) and United Nations organization (UNCTAD, 2011; UNESCAP, 2011). There is a multiplier called trade multipliers which show the ratio between the total volume of seaborne (container) growth and GDP growth. It is an essential ratio that is often used in port traffic or throughput forecasting since it tends to be associated with economic growth prospect. As the International Monetary Fund announced, the global economic growth last year is just at 3%. If back then in 1990s, a GDP growth of 3% could have meant 10.5% or greater container trade growth, in 2011-2016, the case would be at just 4% growth. But, GDP alone is often vague in certain case studies in shorter time-horizon (short to medium-term) i.e. quarterly or monthly seasonality of throughput cannot be well-accommodated by GDP (Hackett, 2012).

### 2.4.2 Exchange Rate

The exchange rate between two countries is "the price at which residents of those countries trade with each other" (Mankiw, 2016). A rise in the exchange rate is called an appreciation while a fall in the exchange rate is called a depreciation. When the domestic currency enduring appreciation, it buys more of the foreign currency. While when it depreciates, it buys less. An appreciation is also called as a strengthening of the currency, and a depreciation is sometimes called a weakening of the currency. There are two types of exchange rate: nominal exchange rate and real exchange rate. The nominal exchange rate is the relative price of the currencies of two countries while the real exchange rate is the relative price of the goods of two countries. Another terminology for real exchange rates is the terms of trade. If the real exchange rate is high, foreign goods are relatively cheap and domestic goods are relatively expensive. Otherwise, foreign goods are relatively expensive, and domestic goods are relatively cheap. The relation between real exchange rate and nominal exchange rate can be summarized with this calculation.

$$Real\ Exc.Rate = Nominal\ Exc.Rate \times Ratio\ of\ Price\ Levels \qquad (2.1)$$

$$Real\ Exc.Rate = Nominal\ Exc.Rate \times \frac{Price\ of\ Domestic\ Good}{Price\ of\ Foreign\ Good} \qquad (2.2)$$

With that being said, it is common for exchange rates to be used in trade analysis. However, exchange rate alone as determinants of container throughput is subject to variability as the rate keeps moving each time. In order to accommodate, the time-varying characteristics, new measurement is introduced, exchange rate volatility. The one that will be used in this research is based on Tenreyro (2006) with the formula as follow.

$$ERvol_{ijt} = std.dev.\left[ln\left(ER_{ijt,m}\right) - ln\left(ER_{ijt,m-1}\right)\right] \quad (2.3)$$

where

$ERvol_{ijt}$ : exchange rate volatility between country i and j in year t

$ER_{ijt,m}$ : nominal exchange rate between country i's currency against country j in month m and year t

Since the calculation is for a one-year period, it is considered as short-run volatility. If the value of $ERvol_{ijt}$ equals to zero, it indicates no volatility in the exchange rate as in the case of fixed exchange rate regime. Previously, this indicator has been studied under the determinants of trade (Nicita, 2013). United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) on their study has stated how factors impacting the volume of container imports and exports are wide, including exchange rate fluctuations, changes in economic structure, etc. (UNESCAP, 2007). From Kim (2016) study, there is a positive and significant relationship between nominal exchange rate and port cargo throughput.

### 2.4.3 Bilateral Trade

Bilateral trade is related with export import between two countries. In broader context it involves the relativity to global trade. World Bank provides several trade indicators and one of them is trade intensity index (TII). The usage of trade intensity index that they give is "to determine whether the value of trade between two countries is greater or smaller than would be expected on the basis of their importance in world trade" (World Bank, n.d.). The trade intensity index provided by Deardoff (1998) has the formula as follow.

$$Bilateral\ Trade\ Intensity_{ijt} = \frac{Exp_{ijt} + Imp_{ijt}}{GDP_{it}GDP_{jt}} \times \frac{GDP_{wt}}{2} \quad (2.4)$$

where

$Exp_{ijt}$ : the nominal exports from country i to country j (where the ports are located) at time t

$Imp_{ijt}$ : the nominal imports of country i from country j (where the ports are located) at time t

$GDP_{it}$, $GDP_{jt}$ : the GDP of country i and j at time t respectively

$GDP_{wt}$ : the world's GDP at time t

Deardorff shows that if there are no trade barriers and if preferences are homothetic, the bilateral trade intensity index value is above or equals to 1. The port throughput and bilateral trade have been explored theoretically (UNCTAD, 2011; RITA, 2011) and empirically (Clark, Dollar, & Micco, 2004; Biermann, 2012). Containerized shipment is indeed related with the pattern in overall international trade (RITA, 2011). In any case, containerization does affect the volume of bilateral trade flow. (Liu & Park, 2011; Biermann, 2012). Bilateral trade is also used in forecasting international maritime container throughput (APEC, 2009).

Another issue regarding bilateral trade besides the intensity of the export import itself is the presence of free-trade agreement or free-trade area. Free-trade agreement in the simplest definition is when the members of a preferential trading can go as far as to eliminate all tariffs and quantitative import restrictions among themselves, it can be said as a free-trade agreement (Frankel, 1997). This preferential trading can be made based on regions (e.g. ASEAN's Free Trade Area) or non-regions (US-Israel FTA). When a country is incorporated in a free-trade, it increases the potential international trade with the members of the free-trade area or agreement. In terms of export, the presence of free-trade does affect the volume increase (Tenreyro, 2006).

## 2.5 Econometrics

Econometrics can be defined as the discipline that utilizes the tools of economic theory, mathematics, and statistical inference to analyze economic phenomenon (Goldberger, 1964). Another definition of econometrics is "the quantitative analysis of actual economic phenomena based on the concurrent development of theory and observation, related by appropriate methods of inference" (Samuelson, Koopmans, & Stone, 1954). Sometimes, an econometric model is a derivation from a formal economic model, but in other cases, it is based on "…informal economic reasoning and intuition" (Wooldridge, 2016). Econometric analysis has main objectives of estimating the parameters in the model and testing the hypotheses about these parameters. The validity of an economic theory and the effects of certain policies rely on the values and signs of the parameters (Wooldridge, 2016).

Econometrics focuses on the analysis of *nonexperimental data* or *observational data* which is not based on controlled experiments; it is obtained from real conditions on individuals, firms, or segments or the economy. The most common tool used in econometrics is least squares regression. This method is used extensively since it can describe the relationship between variables with causality. Least squares regression uses *least squares estimator* which is "an estimator that minimizes a sum of squared residuals" (Wooldridge, 2016). Later on, the regression analysis can be developed even more complex due to data characteristic, assumption violations, nonstationary, etc. (Ariefianto, 2012).

## 2.6 Statistical Analysis

In this section, the literature review on some statistics theory related to this research topic is presented. It covers the information on panel data, panel data regression, how the model can be tested, and tests for assumption violations.

### 2.6.1 Panel Data

Panel data can be defined as a set of data involving *cross-sectional data* and *time-series data. Cross-section data* are a set of observations on one or more variables collected at the same point in time. For instance, the pricelist of fifteen types of fruits in Supermarket A for the year of 2019 means that there are 15 observations. While *time-series data* are "a set of observations on the values that a variable takes at different times" (Gujarati & Porter, 2008). The data can be collected at regular time intervals, such as daily, weekly, monthly, quarterly, annually, etc. For instance, the pricelist of fruit A for the year of 2019 presented in weekly. Meaning that, the data has 52 observations.

For *panel data* or *longitudinal data*, it is a pooled data in which the same cross-sectional unit (e.g. individuals, cities, firms, etc.) is surveyed across time. Take example of the case that will be studied in this research; a panel data set on container throughput from four major ports in Indonesia for the year of 2009 – 2018. Each port has 10 annual observations of container throughput. On the other hand, a set of *pooled data* combines the observations regardless their time or the cross-section. Thus, the pooled one has 40 observations of container throughput. If all the ports have the same number of observations, the data is called a *balanced panel*. If the number of observations is unequal for each port, it is called *an unbalanced panel.* Besides the classification based on the number of observations for each cross-section unit, panel data can also be classified as *short panel* and *long panel*. If the number of cross-sectional subject is greater than the number of time period, it is called a *short panel*. It is *long panel* if the number of time period is greater than the number of cross-sectional subject.

By using panel data, one can observe the omitted or unobservable variables that—despite being different (e.g. different ports, different cities)—do not vary over time. According to Hsiao (2003) and Klevmarken (1989) [as cited in (Baltagi, 2005)], the benefits of using panel data are as follow.

- Ability to control individual heterogeneity effect by allowing subject-specific variables.
- More informative data, more variability thus less collinearity among the variables and more efficiency.
- Better ability to study the dynamics of adjustment. With panel data, how independent variables estimate the dependent variable and how this share varies over time are explained better.
- Ability to identify and measure effects that can barely be detected in pure cross-section or pure time-series data.
- Allowing to construct and test more complicated behavioral models.

In spite of various benefits, panel data also have limitations of application as described in the following list.

- Difficulty in sample designs and data collections.
- Distortion of measurement errors.

- Selectivity problems in terms of self-selectivity (some units of subjects decided not to occur in the sampling; the decision leads to ineligibility to participate in the sampling), nonresponse (respondents decided not to respond some questions), or attrition (some units are dropped out from the sample as they are no longer available).
- Limited time-series dimension
- Dependency of cross-section.

2.6.2 Panel Data Regression

Panel data regression is one of the variety and development of classical linear regression model (CLRM). Broadly speaking, regression analysis deals with the dependence of one variable on other variables and it is important to note that this does not necessarily imply a causation (Gujarati & Porter, 2008). Panel data regression extends the classic framework by accommodating cross-section and time-series data into the regression analysis. However, since such data involves both cross-section and time-series data, problems faced by cross-section (e.g. heteroscedasticity) or time-series (e.g. autocorrelation) should be addressed properly to avoid biases. Besides, another problem that may arise is the cross-correlation in individual units at the same point in time.

In analysis of panel regression, there are several approaches to model the experiment that can address one or more of these problems:

a. Pooled OLS Estimation or Common Effect Model (CEM)

   It is defined as "an Ordinary Least Square estimation with independently pooled cross sections, panel data, or cluster samples, where the observations are pooled across time (or group) as well as across the cross-sectional units" (Wooldridge, 2016). This is a naïve approach since it masks the effect of cross-section subject and time-varying variable in the model. The general model of this approach can be seen in the following equation.

$$Y_{it} = \beta_1 + \beta_2 X_{it2} + \beta_3 X_{it3} + \cdots + \beta_k X_{itk} + u_{it} \qquad (2.5)$$

   where:

$Y_{it}$ : dependent variable

$\beta_1$ : intercept

$\beta_k$ : regression coefficient of variable k

$X_{itk}$ : k-th explanatory variable of subject i in time period t

$u_{it}$ : error term of each subject i in time period t

b. Fixed Effect Model (FEM)

By using this model, the unobserved effects are allowed to be correlated with any explanatory variables in each time period (Wooldridge, 2016). Thus, the intercept for each subject may differ among the cross-sectional units since the subject may have special characteristics that can affect the dependent variable (Gujarati & Porter, 2008). To differentiate the effect between cross-section subject, FEM uses dummy variables known as the least-squares dummy variable (LSDV) model. This model is appropriate if the individual-specific intercept may be correlated with one or more explanatory variables. However, using LSDV means consuming a lot of degrees of freedom. Adapted from Gujarati and Porter (2008), the general model of fixed effect model (FEM) with multiple explanatory variables can be written as the following equation.

$$Y_{it} = \alpha_i + \beta_{1i} + \beta_2 X_{it2} + \beta_3 X_{it3} + \cdots + \beta_k X_{itk} + u_{it} \tag{2.6}$$

where:

$Y_{it}$ : dependent variable

$\alpha_i$ : fixed effect or unobserved effect of subject i

$\beta_{1i}$ : intercept of subject i

$\beta_k$ : regression coefficient of variable k

$X_{itk}$ : k-th explanatory variable of subject i in time period t

$u_{it}$ : error term of each subject i in time period t

The above equation is a **one-way model** of fixed effect. It is called so because the model allows the intercept to differ across subjects; each entity's intercept does not vary over time or time-invariant. Unobserved effect, $\alpha_i$, is an unobserved variable in the error term that does not change over time. For **two-way model** of fixed effect, it allows both individual and time effect as written in the following equation.

$$Y_{it} = \alpha_i + \delta_t + \beta_{1i} + \beta_2 X_{it2} + \beta_3 X_{it3} + \cdots + \beta_k X_{itk} + u_{it} \qquad (2.7)$$

The difference with the one-way model is the additional time-effect represented by $\delta_t$. This time-effect exists if it is believed that the dependent variable changes over time because of factors such as technological changes, regulation changes, etc.

c. Error Component Model (ECM) or Random Effect Model (REM)

This model uses Generalized Least Square (GLS) estimator in which the unobserved effect is assumed to be uncorrelated with the explanatory variables in each time period (Wooldridge, 2016). Thus, the intercept for each subject is "a random drawing from a much larger population with a constant mean value" (Gujarati & Porter, 2008). The individual intercept is expressed as a random variable with constant mean value. Hence, the common intercept represents the mean value of all the cross-sectional intercepts and the error component εi represents the error term of the individual intercept. This model is appropriate if the (random) intercept of each cross-sectional subject is uncorrelated with the explanatory variables. ECM also allows variables such as gender, religion, and ethnicity, which remain constant for a given subject, to be introduced in the model. Meanwhile, FEM prohibits that due to all such variables are collinear with the subject-specific intercept. The general model of ECM can be summarized in the following equation.

$$Y_{it} = \beta_1 + \beta_2 X_{it2} + \beta_3 X_{it3} + \cdots + \beta_k X_{itk} + \varepsilon_i + u_{it} \qquad (2.8)$$

$$Y_{it} = \beta_1 + \beta_2 X_{it2} + \beta_3 X_{it3} + \cdots + \beta_k X_{itk} + w_{it} \qquad (2.9)$$

where:

$Y_{it}$ : dependent variable

$\alpha_i$ : fixed effect or unobserved effect of subject i

$\beta_1$ : common intercept (the individual intercept represented as a random variable).

$\beta_k$ : regression coefficient of variable k

$X_{itk}$ : k-th explanatory variable of subject i in time period t

$u_{it}$ : error term of each subject i in time period t

$\varepsilon_i$ : random error term of the individual intercept

$w_{it} = \varepsilon_i + u_{it}$

In order to select which method is the most suitable to be used for further analysis, a set of tests can be done beforehand.

a. Chow Test

Chow test is an F-test to determine whether there is a difference across two groups in a multiple regression function (Wooldridge, 2016). This test is done to decide whether pooled OLS estimation (CEM) or FEM that should be chosen. It has two basic assumptions: the error terms in the sub-period regressions are normally distributed with the same variance (homoscedasticity) and the two error terms $u_{1t}$ and $u_{2t}$ are independently distributed.

Hypothesis:

$H_0$: the CEM and FEM estimators do not differ substantially (proceed with CEM)

$H_A$: the CEM and FEM estimators differ substantially (proceed with FEM)

b. Hausman Test

On the contrary with Chow test, Hausman test is done to check the suitability between REM and FEM. It test the cross-section random effects with Chi-Square value, $\chi^2$.

Hypothesis:

$H_0$: the REM and FEM estimators do not differ substantially (proceed with REM)

$H_A$: the REM and FEM estimators differ substantially (proceed with FEM)

c. Lagrange Multiplier Test

Lastly, a Langrage Multiplier (LM) test can be used to select between CEM or REM.

Hypothesis:

$H_0$: the CEM and REM estimators do not differ substantially (proceed with CEM)

$H_A$: the CEM and REM estimators differ substantially (proceed with REM)

The relationship between those tests mentioned can be summarized as shown in the diagram below.

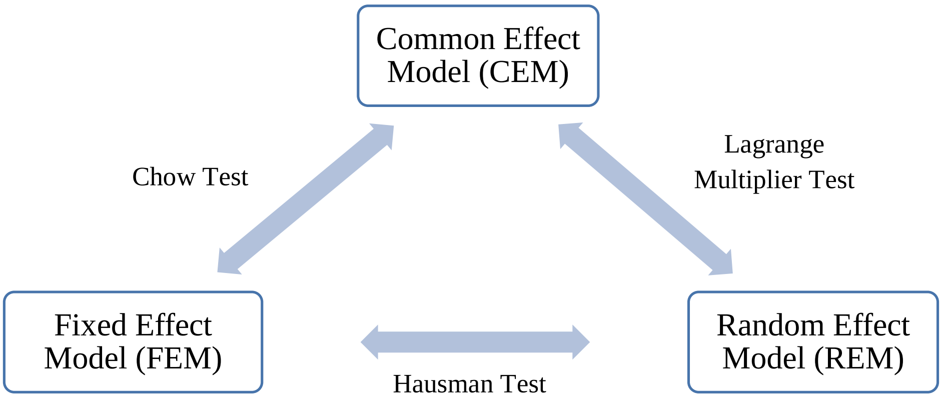


Figure 2.7 Approach selection tests for panel data regression

### 2.6.3 Assumption testing

As classic linear regression model has, panel data regression also holds the assumption of BLUE (Best Linear Unbiased Estimator).

a. Multicollinearity test

Multicollinearity occurs when a perfect linear relationship exists among some or all explanatory variables in a regression model (Gujarati & Porter, 2008). The existence of multicollinearity is undesirable since it results a biased model where the independent variables explain one another. Common detection method of multicollinearity is through Variance Inflation Factor (VIF), yet it does not free of criticism in terms of how it is related with variance. High VIF which indicates high collinearity can be counterbalanced by low variance hence, high collinearity may not necessarily cause high error (Gujarati & Porter, 2008). The alternative to detect multicollinearity is by using condition index (CI) as parameters. If CI is between 10 and 30, there is moderate to strong multicollinearity and if CI > 30 there is severe multicollinearity.

b. Autocorrelation test

According to Kendall and Buckland (1971) [as cited in (Gujarati & Porter, 2008)], autocorrelation can be defined as "correlation between members of series of observations ordered in time [as in time series data] or space [as in cross-sectional data]". In the panel regression context, it is assumed that such autocorrelation does not exist in the error term, $u_{it}$. The autocorrelation can be tested with Wooldridge procedures. Under the null hypothesis of the original idiosyncratic errors are uncorrelated, the residuals from this equation should have an autocorrelation coefficient of -0.5 (Wooldridge, 2016). Compare the coefficient of the lagged residuals with the autocorrelation coefficient though formal test of Wald hypothesis test.

Hypothesis:

$H_0$: Residuals have no first-order autocorrelation

$H_A$: Residuals have first-order autocorrelation

Reject the null hypothesis if the probability of F-statistic is less than 5% significance level.

c. Heteroscedasticity test

Heteroscedasticity test is done to check whether irregular pattern of variation of the error term exists. The variance of each residual should be constant to obey the assumption of homoscedasticity (Gujarati &

Porter, 2008). The most common detection method to this assumption is the White's General Heteroscedasticity Test. If the probability of the test set against the significance level 5% is higher, it means that there is no heteroscedasticity existing in the error term. Another parameter is by using panel cross-section heteroscedasticity likelihood ratio (LR) test.

Hypothesis:

$H_0$: Residuals are homoscedastic

$H_A$: Residuals are not homoscedastic

With the null hypothesis as shown above, the heteroscedasticity test will reject the null hypothesis if the p-value is less than 5% significance level.

### 2.6.4 Model Testing

After developing the panel regression model, the goodness-of-fit of the model should be assessed. There are three common tests used which are partial significance test (t-test), simultaneous significance test (F-test), and coefficient determination test ($R^2$ test).

a. Partial significance test (t-test)

The partial significance test checks on how each explanatory variable significantly affecting the dependent variable. It is done by comparing the p-value of each explanatory variable with the significance level of 5%.

Hypothesis:

$H_0$: the explanatory variable is partially insignificant towards the dependent variable

$H_A$: the explanatory variable is partially significant towards the dependent variable

If the probability of t-statistics < significance level (0.05), the null hypothesis is rejected.

b. Simultaneous significance test (F-test)

The simultaneous significance test or F-test examines all the explanatory variables in terms of how they affect the dependent variable simultaneously.

Hypothesis:

$H_0$: all explanatory variables are not simultaneously significant towards the dependent variable

$H_A$: all explanatory variables are simultaneously significant towards the dependent variable

If the probability of F-statistics < significance level (0.05), the null hypothesis is rejected.

c. Coefficient determination ($R^2$) test

This test is the prominent test in determining how good the model explains the problem. Coefficient determination has value ranging between 0 and 1. The greater the value of $R^2$ (closer to 1) implies that the explanatory variables able to explain all the information required in response to the changes in dependent variable.

## 2.7 Previous Researches

Before going further to conduct a research, there should be an attempt to read and reviews various literatures and researches that have been done previously. Thus, the position of the study in academic research can be identified. By reviewing how previous researches are, the author can enrich their knowledge on the research area and get the hang of it.

In the context of econometrics analysis on maritime logistics and port operations alone, the area commonly being researched are varying. Some researches focus on the port efficiency and internal factors. Aqmarina & Achjar (2017) previously investigated the relationship between port total traffic volumes with several internal factors of port in Indonesia such as, turn-around time, idle time, berth occupancy rate, operating surplus per ton, rate of return, number of employees, cargo equipment and operating expense. Paing & Prabnasak (2019) analyzed how port performance indicators such as numbers of berths, berth length, terminal, area, total number of quay container crane, total number of transfer crane, number of reach stacker, number of frock lift, and number of ship calls per year affect the port container of Myanmar's major ports. Both studies used the same method which is multiple linear regression.

One of the early study in this area, analyzed the container throughput determinants with combining the port performance indicators and added GNP or gross national production into the model (Song & Han, 2003). This research is one of the foundation that leads to combination of various economic variables into the container throughput context.

Liu, L and Park, G K (2011) studied the major ports in Korea and China by considering the port's hinterland GDP and export import volume. It was also one of a few that investigated the role of government's investment on the port towards the container throughput. The research also compared the distinct factors that affect the container throughput the most for each country. For Indonesia's case, Haris (2019) studied as much as 26 independent variables consisting of 13 macroeconomic factors, 4 traffic factors, and 9 internal port performance factors on the cargo throughput of Belawan International Container Terminal. In contrast with the studies mentioned, Vitsounis et al. (2014) analyzed the determinants of port throughput in the form of cross-correlation index to signal a convergence or synchronicity between port pairs. This study set its determinants mainly on macroeconomic and bilateral context e.g. trade intensity index, GDP cross-correlation index, industrial production volume, and financial openness, yet it also included two shipping variable such as transportation cost and average world container fleet deployment. Another distinct approach was done by Cho, H S (2014) that analyze the determinants effects on container throughput to further analyze it on logistics cost. It is done with the structural equation modelling (SEM). 125 countries were set as the object.

In terms of determining which aspects wanted to be studied, the possibilities are endless. Hence, this research would like to point out how the research is different with the existing ones. Below is the list of some notable previous studies related with this research. Later on, there will be a matrix that compiles the methods and objectives from previous studies and how would this research approaches.

Table 2.2 Previous researches related to this research

| Year | Type | Author | Title | Object | Method | Description |
|---|---|---|---|---|---|---|
| 2011 | Paper | Liu, L. and Park, G-K | Empirical analysis on influence factors to container throughput in Korea and China Ports | 2 Korea's major ports and 4 China's major ports | Fixed Effect Model | All variables tested are affecting significantly with the strongest variable for Korea ports are geographical position and service level while for China ports are hinterland economic level and government attitude |
| 2014 | Paper | Vitsounis, T.K., Paflioti, P. and Tsamourgelis, I. | Determinants of container ports throughput convergence. A business cycle synchronicity analysis | 36 ports from 25 countries | Generalized Methods of Moments | Macroeconomic factors (GDP, industrial production similarity, financial openness) and shipping variable are significant to the container throughput |
| 2014 | Paper | Cho, H. S. | Determinants and Effects of Logistics Costs in Container Ports: The Transaction Cost Economics Perspective | 125 countries | Structural Equation Modelling (SEM) | Logistics costs in container ports are negatively related to container traffic volume. Container traffic is affected by its internal capabilities i.e. accessibility is positively related. |
| 2017 | Paper | Aqmarina, A. and Achjar, N. | Determinants of Port Performance – Case Study of 4 Main Ports in Indonesia (2005–2015) | 4 main ports in Indonesia | Pooled OLS Estimation (Common Effect Model) | All variables tested are affecting significantly except for operating surplus per ton. The rest of determinants are turn-around time, idle time, berth of occupancy rate, rate of return, number of employee and cargo equipment |

| Year | Type | Author | Title | Object | Method | Description |
|---|---|---|---|---|---|---|
| 2019 | Dissertations | Haris, T. | An econometric analysis for cargo throughput determinants in Belawan International Container Terminal, Indonesia | Belawan International Container Terminal (BICT) | Classical Linear Regression Model | From 26 independent variables suspected (13 macroeconomic factors, 4 traffic factors, 9 internal port performance factors), only 8 variables remain significant in the end. Additional output: proposed strategies in response to the variables. |
| This research | | | Analysis of Container Throughput Determinants: A Case Study on Indonesia’s Four Major Ports in Global Maritime Trade | 29 ports from 26 countries | Fixed Effect Model; Random Effect Model | Obtain the relationship between the maritime logistics and macroeconomics factors with the port container throughput. Obtain the behavior in each port clusters in respect to Indonesia's ports. |

Table 2.3 Research position

| | Author | Liu, L. & Park, G-K (2011) | Vitsounis, et al. (2014) | Cho, H. S. (2014) | Aqmarina, A. & Achjar, N. (2017) | Haris, T. (2019) | This research |
|---|---|---|---|---|---|---|---|
| **Method** | Fixed Effect Model | ✓ | | | ✓ | | ✓ |
| | Pooled OLS Estimation | | | | ✓ | | |
| | Random Effect Model | | | | | | ✓ |
| | Estimated Generalized Least Squares with Cross-Section Weights | | | | | | ✓ |
| | Generalized Methods of Moments | | ✓ | | | | |
| | Classical Linear Regression | | | | | ✓ | |
| | Structural Equation Modelling | | | ✓ | | | |
| **Objective** | Identify the relationship between DV and EV | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Identify the relationship in the clusters | | ✓ | | | | ✓ |
| | Identify potential new port partners | | | | | | ✓ |

# CHAPTER 3
# RESEARCH METHODOLOGY

In this chapter, the steps or activities involved in conducting this research will be explained. The methodology will be complemented with flowchart and description of the steps.

## 3.1 Flowchart of Methodology

In order to structure the thinking process on how the research will be conducted, below is the flowchart of methodology that will be applied in this research.

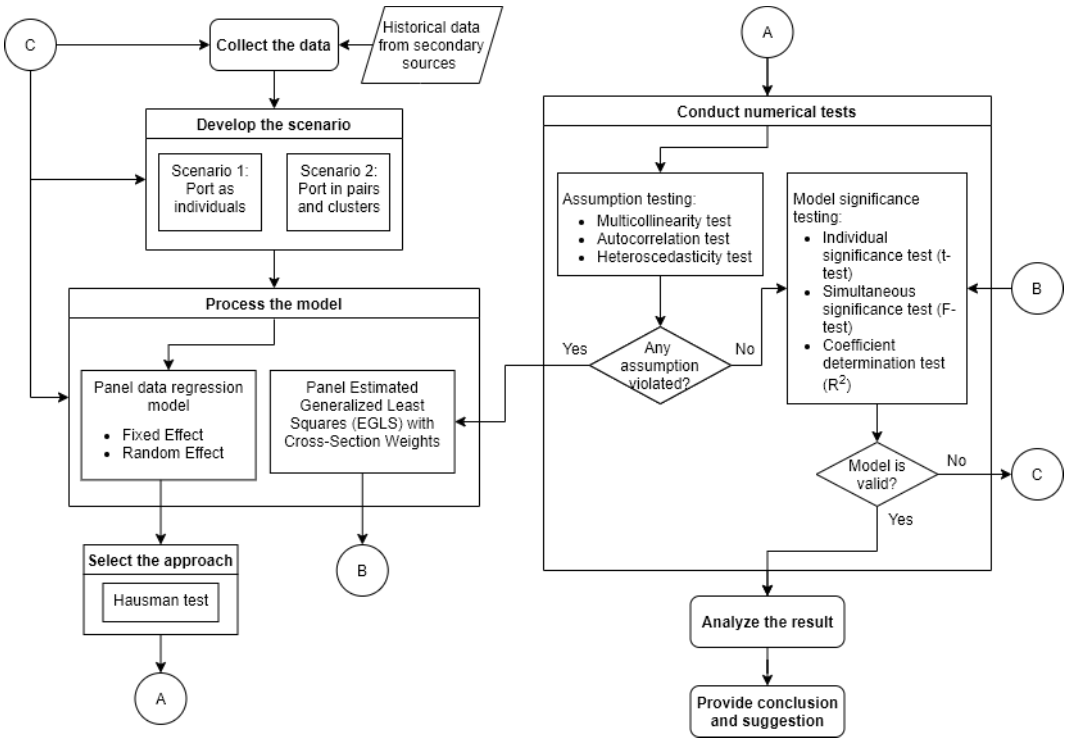


Figure 3.1 Flowchart of research methodology

From the figure above, there are several steps to be done in this research. The more detailed explanation of each process will be described in the following subchapters.

## 3.2 Methodology Description

In this section, the explanation of steps required to conduct this research is described in detail.

### 3.2.1 Research Hypotheses

There are several hypotheses willing to be tested and proven through this research. Based on the preliminary study, the following hypotheses emerge.

Table 3.1 List of hypotheses to be tested in this research

| No | Category | Hypothesis |
|---|---|---|
| 1 | Maritime logistics | **Hypothesis 1:** There is a positive relationship between Port Liner Shipping Connectivity Index (PLSCI) and port container throughput. |
| | | **Hypothesis 2:** There is a positive relationship between Liner Shipping Bilateral Connectivity Index (LSBCI) and port container throughput. |
| | | **Hypothesis 3:** There is a positive relationship between the existence of multimodal facility in port and port container throughput. |
| 2 | Macroeconomics | **Hypothesis 4:** There is a positive relationship between port hinterland's gross domestic product (GDP) and port container throughput. |
| | | **Hypothesis 5:** There is a positive relationship between trade intensity index (TII) and port container throughput. |
| | | **Hypothesis 6:** There is a negative relationship between exchange rate volatility and port container throughput. |
| | | **Hypothesis 7:** There is a positive relationship between the implementation of free-trade agreement and port container throughput. |
| 3 | Port effects | **Hypothesis 8:** There is a significant effect from port on port container throughput. |
| 4 | Cluster effects | **Hypothesis 9:** There is a significant effect from port clustering on port container throughput. |

### 3.2.2 Data Collection

This research investigates the determinants or variables affecting the port container throughput during the period of study (2009 – 2018). There are 8 variables incorporated in this research with 1 dependent variable (container throughput) and

7 explanatory variables divided into two categories: maritime logistics factors (3 variables) and macroeconomic factors (4 variables). The variables used in this research are described in the following table.

.

Table 3.2 List of variables used for the research

| No | Category | Variable | Symbol | Description | Unit or value | Reference | Scenario 1 (individual) | Scenario 2 (pair) |
|---|---|---|---|---|---|---|---|---|
| | Dependent variable | | | | | | | |
| 1 | | Container throughput | CT | The volume of containers handled in port i over time. | TEU | Kim, (2016); Liu & Park, (2011) | ✓ | ✓ |
| | Explanatory variable(s) | | | | | | | |
| 2 | Maritime logistics | Port Liner Shipping Connectivity Index | PLSCI | An index that measures the connectivity performance of port i. | ~ | - | ✓ | |
| 3 | | Liner Shipping Bilateral Connectivity Index | LSBCI | An index that measures the connectivity performance of country i and j. | ~ | Fugazza & Hoffmann (2017) | | ✓ |
| 4 | | Multimodal facility | MM | A dummy variable that represents whether port i has the facility for multimodal transportation e.g. railways connection, airport connection. | Binary (0 or 1) | - | ✓ | |
| 5 | Macroeconomics | Hinterland gross domestic product | GDP | Total nominal value of regional gross domestic product of port i's hinterland area. | $ | Liu & Park (2011); Vitsounis, Paflioti, & Tsamourgelis, (2014); Haris, (2019); Tenreyro, (2006) | ✓ | ✓ |
| 6 | | Trade Intensity Index | TII | An index that measures trade intensity between the country of port i and j. | ~ | Vitsounis, Paflioti, & Tsamourgelis, (2014); Rana, (2007) | | ✓ |

| **No** | **Category** | **Variable** | **Symbol** | **Description** | **Unit or value** | **Reference** | Scenario 1 (individual) | Scenario 2 (pair) |
|---|---|---|---|---|---|---|---|---|
| 7 | | Exchange rate volatility | ER | The measurement of exchange rate variability in short-run for the country's currency of port i against port j. | ~ | Kim, (2016); Tenreyro, (2006) | ✓ | ✓ |
| 8 | | Free-trade agreement | FTA | A dummy variable that represents whether the country of port i location has free-trade agreements with the country of port j. | Binary (0 or 1) | Tenreyro, (2006) | | ✓ |

The data for each variable is collected in regards to the research sample. The selection of sample is based on the top 35 countries with the highest container throughput intersected with the highest exporters to and importers of Indonesia. Then, the port selection from each country refers to the major ports only based on its container throughput, since one of the main objectives for this study is the clustering of ports across Indonesia with the overseas port. For Indonesia's port sample, the chosen ports are the representative of each region of state-owned port operators (Pelabuhan Indonesia or Pelindo). There are Belawan Port (PT Pelindo I—Western area), Tanjung Priok Port (PT Pelindo II—main hub), Tanjung Perak Port (PT Pelindo III—Eastern-Central area), and Makassar Port (PT Pelindo IV—Eastern area). Thus, even though there is a larger port such as Tanjung Emas (located in Central Java), this option is neglected for a more balanced analysis in terms of coverage area of the port. The full list can be seen in the following table.

Table 3.3 List of sample selected

| No | Region | Country | Port |
|---|---|---|---|
| 1 | Eastern Asia | Taiwan | Kaohsiung |
| 2 | | Hongkong | Hongkong |
| 3 | | China | Shanghai |
| 4 | | South Korea | Busan |
| 5 | | Japan | Tokyo |
| 1 | ASEAN | Indonesia | Belawan |
| 2 | | | Tanjung Priok |
| 3 | | | Tanjung Perak |
| 4 | | | Makassar |
| 5 | | Singapore | Singapore |
| 6 | | Malaysia | Port Klang |
| 7 | | Thailand | Laem Chabang |
| 8 | | Philippines | Manila |
| 9 | | Vietnam | Ho Chi Minh City |
| 10 | | Cambodia | Sihanoukville |
| 11 | | Myanmar | Yangon |
| 1 | Oceania | Australia | Melbourne |
| 2 | | New Zealand | Tauranga |
| 1 | Northern America | USA | Los Angeles |
| 2 | | Canada | Vancouver |
| 1 | Europe | Italy | Gioia Tauro |
| 2 | | Spain | Algericas |
| 3 | | Netherlands | Rotterdam |

| No | Region | Country | Port |
|---|---|---|---|
| 4 | | UK | Felixstowe |
| 5 | | Germany | Hamburg |
| 6 | | Belgium | Antwerp |
| 7 | | France | Havre |
| 8 | | Greece | Piraeus |
| 9 | | Poland | Gdansk |
| Total sample | | **26 countries** | **29 ports** |

The analysis later on will be based on two different scenarios. The first scenario will inspect the port as individuals. While the second scenario will analyze the port in pairwise resulting a total 812 pairs. The scenario will be discussed in the next subchapter.

Using the second scenario, the sample will be coded with dummy variables indicating unique markets. It is based on the busiest lane in maritime logistics—Mainlane East-West—in which Indonesia is located. There are four clusters to be studied.

1. Intra-Asia cluster. The cluster consists of pairwise among the four major ports of Indonesia and Asian ports.
2. Indonesia-Europe cluster. The cluster consists of pairwise between the four major ports of Indonesia and European ports
3. Indonesia-Oceania cluster. The cluster consists of the four major ports of Indonesia and Oceanian pairwise ports.
4. Indonesia-Trans-Pacific cluster. The cluster consists of pairwise between the four major ports of Indonesia and West-Coast America.

After sample is determined, the data gathering can be proceeded. The main source of data that will be used in this research is gathered from secondary data. It is elaborated from various reports of credible institutions such as Ministry of Transportation, United Nations Conference on Trade and Development (UNCTAD), Statistics Indonesia or Badan Pusat Statistik (BPS), and World Bank Group. The data requirement is described in the following table.

Table 3.4 Data requirements

| No | Type of data | Variables related | Description | Data source | Scenario 1 | Scenario 2 |
|---|---|---|---|---|---|---|
| 1 | Container throughput | CT | The volume of containers handled in port i over time | Clarksons Research; port authorities website and report; UNCTAD Stat | ✓ | ✓ |
| 2 | Port Liner Shipping Connectivity Index | PLSCI | An index that measures the connectivity performance of port i and j | UNCTAD Stat | ✓ | |
| 3 | Liner Shipping Bilateral Connectivity Index | LSBCI | An index that measures the connectivity performance of country i and j | UNCTAD Stat | | ✓ |
| 4 | Multimodal facility | MM | Availability of the facility for multimodal transportation in port i e.g. railways connection, airport connection | Port authorities website and reports | ✓ | |
| 5 | Hinterland area of each port | GDP; TII | List of area or regions that become port i's hinterland | Port authorities website and reports | ✓ | ✓ |
| 6 | Gross regional domestic product | GDP; TII | Total nominal value of regional gross domestic product of port i's hinterland area | World Bank; statistics center or database from each country; author's calculations | ✓ | ✓ |
| 7 | Nominal export value | TII | Bilateral nominal value of exports in merchandise trade from country i to country j (where the ports are located) | World Bank; UNCTAD Stat | | ✓ |

| No | Type of data | Variables related | Description | Data source | Scenario 1 | Scenario 2 |
|---|---|---|---|---|---|---|
| 8 | Nominal import value | TII | Bilateral nominal value of imports in merchandise trade to country i to from country j (where the ports are located) | World Bank; UNCTAD Stat | | √ |
| 9 | World's gross domestic product | TII | Nominal value of the world's gross domestic product | World Bank; statistics center or database from each country | | √ |
| 10 | Monthly exchange rates | ER | Monthly exchange rates of the country's currency of port i against US Dollars | IMF Database; central bank websites and reports | √ | √ |
| 11 | Free-trade agreement | FTA | List of free-trade agreements between the country of port i and j | World Trade Organization | | √ |

### 3.2.3 Scenario Development with Panel Regression

There are two types of scenario that will be inspected in this research. These two scenarios represent the objectives of this research.

a. The first scenario is related to how the container throughput of a port as individuals are changing in response to the maritime logistics and macroeconomics factors.
b. The second scenario is related to how the container throughput of a port are changing in response to the determinants in the context of port pairing and port clustering. By using dummy variables indicating different clusters, it can be analyzed how each port cluster influences the container throughput in Indonesia's four major ports.

These two scenarios are further developed using panel regression as the base model. As explained in the previous subchapter that the data is consisted of time-series and cross section hence the base model chosen is panel regression. Panel regression extends the classic framework of linear regression by accommodating cross-section and time-series data into the regression analysis. The mathematical model that can describe the scenarios mentioned above are explained in the following sections.

#### *3.2.3.1 Scenario 1: Port as Individuals*

The first scenario is formulated to observe the behavior of the port as individuals hence the number of observations is 290 (29 cross section within 10-year period). The general model estimation that will be developed can be seen in the following equations.

$$\ln CT_{it} = \alpha_i + \beta_0 + \beta_1\, PLSCI_{it} + \beta_2\, MM_{it} + \beta_3\, ln\, GDP_{it} + \beta_4\, ER_{it} + u_{it} \tag{3.1}$$

where

| | |
|---|---|
| i, t, k | : port/country, time period, and parameter respectively with i = 1, 2, …, 29; t = 1, 2, …, 10; and k = 1, 2, …, 8 |
| $CT_{it}$ | : container throughput of port i at time t |
| $\alpha_i$ | : fixed effect or unobserved effect of port i |
| $\beta_0$ | : intercept or constant parameter |

$\beta_k$ : coefficient of k-th parameter

$PLSCI_{it}$ : Port Liner Shipping Connectivity Index of port i at time t

$MM_{it}$ : the availability of multimodal facility in port i at time t

$GDP_{it}$ : GDP of port i's hinterland at time t

$ER_{it}$ : exchange rate volatility of country i's currency compared to USD at time t

$u_{it}$ : error term of each port i in time period t

Container throughput, $CT_{it}$, represents the dependent variable of this research associated with four explanatory variables $PLSCI_{it}$, $MM_{it}$, $GDP_{it}$, and $ER_{it}$. Variables expressed in natural logarithm in this scenarios are container throughput, GDP, and export import volume.

### *3.2.3.2 Scenario 2: Port in Pairs*

The second scenario aims to analyze the port in pairwise hence the modification of the model. The pairing is done for all samples excluding the intra-Indonesian ports thus, the total observations will be 8120. The second scenario is summarized as follow.

$$\begin{aligned} ln\, CT_{it} = \alpha_i + \beta_0 + \beta_1\, LSBCI_{ijt} + \beta_2\, ln\, GDP_{it} + \beta_3\, ln\, GDP_{jt} \\ + \beta_4\, TII_{ijt} + \beta_5\, ER_{it} + \beta_6\, ER_{jt} + \beta_7\, FTA_{ijt} + u_{it} \end{aligned} \quad (3.2)$$

where

i, j : port/country pairs with i and j = 1, 2, …, 29;

t, k : time period and parameter respectively with t = 1, 2, …, 10 and k = 1, 2, …, 8

$CT_{it}$ : container throughput of port i at time t

$\alpha_i$ : fixed effect or unobserved effect of port i

$\beta_0$ : intercept or constant parameter

$\beta_k$ : coefficient of k-th parameter

$LSBCI_{ijt}$ : Liner Shipping Bilateral Connectivity Index of country i paired with country j at time t

$GDP_{it}$ : GDP of port i's hinterland at time t

$GDP_{jt}$ : GDP of port j's hinterland at time t

| | |
|---|---|
| $TII_{ijt}$ | : trade intensity index between country i and country j at time t |
| $ER_{it}$ | : exchange rate volatility of country i's currency to USD Dollar at time t |
| $ER_{jt}$ | : exchange rate volatility of country j's currency to USD Dollar at time t |
| $FTA_{ijt}$ | : the presence of free-trade agreement between country i and country j at time t |
| $u_{it}$ | : error term of each port i in time period t |

Container throughput, $CT_{it}$, represents the dependent variable and it is associated with seven explanatory variables $LSBCI_{ijt}$, $DC_{ijt}$, $GDP_{it}$, $GDP_{jt}$, $TII_{ijt}$, $ER_{ijt}$, and $FTA_{ijt}$. Some of the variables expressed in natural logarithm in this scenarios are container throughput and GDP.

For the second scenario, the models are equipped with two types of unobservable effects/fixed effects, $\alpha_i$: Indonesian port effects and cluster effects. As been mentioned in the previous subchapter, the clusters are made to gain better perspective on how the ports associated within a certain region or trade lane. It is expected that unobservable randomness in cross-section can be tamed.

### 3.2.4 Approach Selection

The cross-sectional and time-series data collected are constructed in a way to carry out panel data analysis. The method that will be used to model the port container throughput in this research is using panel data regression. There are several approaches of panel data regression namely common effects model (CEM) or pooled least square (PLS), fixed effects model (FEM), and error component model or random effects model (REM). After scenarios to be tested are developed, the analysis that will be done in this research is using the approach of FEM and REM. These models are developed with the help of EViews 10 software. To determine which approach that statistically defines each scenario best, Hausman test is done to examine the suitability of random effect model over fixed effect model in terms of explaining the problem.

### 3.2.5 Numerical Test

The numerical test included in this step is classified into two types: model significance tests and assumption tests. These tests are done to check how good the regression model is. The regression model tests consist of partial significance test (t-test), simultaneous significance test (F-test), and coefficient determination test ($R^2$ test). The partial significance test checks on how each explanatory variable significantly affecting the dependent variable (port container throughput). Meanwhile, the simultaneous significance test or F-test examines all the explanatory variables in terms of how they affect the dependent variable simultaneously. Lastly on model test is coefficient determination test, which is the prominent test in determining how good the model explains the problem.

The second group of tests is the assumption tests which examine the classic assumption of panel data regression. It consists of multicollinearity test, autocorrelation test, and heteroscedasticity test. Multicollinearity test checks on whether there is any dependency between explanatory variables. Similar with multicollinearity, autocorrelation test examines the independency of residuals but in periodic manner. So it is applied to the time-series data. Finally, heteroscedasticity test is done to the cross-section data; whether the variance of residuals is non-constant or not. If there is any violation found in no autocorrelation and homoscedasticity assumptions, the model should be processed through estimated generalized least squares (EGLS) before it can be analyzed.

# CHAPTER 4
# DATA COLLECTION AND PROCESSING

In this chapter, the data collected will be processed to create the model. The determinants of port container throughput are processed with panel regression modelling so the relation between determinants can be analyzed further.

## 4.1 Data Collection

This subchapter will cover the information on how the data requirement is collected for this research purpose. It includes the data of each variable both dependent and independent ones as well as how the processing of the raw data for some variables before it can be modeled through panel data regression. The data collected is derived from the hypotheses willing to be tested and the variables determined in the model.

### 4.1.1 Container Throughput

Container throughput is the highlight of this research as it is the main object under observation. The container throughput data is at port level in the form of TEUs (Twenty-Foot Equivalent Units). The data is elaborated from various sources such as, UNCTAD Stat, World Shipping Council, and the respective port authority reports. There are container throughput data from 29 ports across 26 countries in the range of 2009 to 2018. The selection of samples is based on the top 35 countries with the highest container throughput intersected with the highest exporters to and importers of Indonesia. Then, the port selection from each country refers to the major ports only based on its container throughput, since one of the main objectives for this study is the clustering of ports across Indonesia with the overseas ports. For Indonesia's port sample, the chosen ports are the representative of each region of state-owned port operators (Pelabuhan Indonesia or Pelindo). There are Belawan Port (PT Pelindo I—Western area), Tanjung Priok Port (PT Pelindo II—main hub), Tanjung Perak Port (PT Pelindo III—Eastern-Central area), and Makassar Port (PT Pelindo IV—Eastern area). Below is the data of the container throughput. Below is the data for container throughputs of the samples selected.

Table 4.1 Container Throughput of 29 Ports Sample from 2009-2018 (in TEUs)

| No | Port | Country | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Kaohsiung | Taiwan | Asia | 8,581,000 | 9,181,000 | .. | 10,460,000 | 10,270,000 | 10,450,000 |
| 2 | Hongkong | Hongkong | Asia | 21,040,000 | 23,699,000 | .. | 19,810,000 | 20,760,000 | 19,600,000 |
| 3 | Shanghai | China | Asia | 25,000,000 | 29,069,000 | .. | 37,130,000 | 40,230,000 | 42,010,000 |
| 4 | Busan | South Korea | Asia | 11,980,000 | 14,194,000 | .. | 19,850,000 | 20,490,000 | 21,660,000 |
| 5 | Tokyo | Japan | Asia | 3,810,000 | 4,284,000 | .. | 4,250,000 | 4,500,000 | 4,570,000 |
| 6 | Belawan | Indonesia | Asia | 718,663 | 795,668 | .. | 907,707 | 1,002,151 | 1,128,913 |
| 7 | Tanjung Priok | Indonesia | Asia | 3,804,000 | 4,714,000 | .. | 5,514,694 | 6,090,000 | 7,640,000 |
| 8 | Tanjung Perak | Indonesia | Asia | 2,270,000 | 3,030,000 | .. | 3,327,000 | 3,553,370 | 3,865,646 |
| 9 | Makassar | Indonesia | Asia | 355,507 | 384,116 | .. | 553,926 | 582,290 | 629,659 |
| 10 | Singapore | Singapore | Asia | 25,866,000 | 28,431,000 | .. | 30,900,000 | 33,670,000 | 36,600,000 |
| 11 | Port Klang | Malaysia | Asia | 7,309,000 | 8,870,000 | .. | 13,200,000 | 13,730,000 | 12,320,000 |
| 12 | Laem Chabang | Thailand | Asia | 4,537,000 | 5,068,000 | .. | 7,220,000 | 7,780,000 | 8,070,000 |
| 13 | Manila | Philippines | Asia | 2,874,000 | 3,154,000 | .. | 4,520,000 | 4,820,000 | 5,050,000 |
| 14 | Ho Chi Minh City | Vietnam | Asia | 3,563,000 | 3,856,000 | .. | 5,990,000 | 6,160,000 | 6,330,000 |
| 15 | Sihanoukville | Cambodia | Asia | 210,500 | 222,000 | .. | 400,187 | 459,848 | 541,228 |
| 16 | Yangon | Myanmar | Asia | 163,692 | 335,346 | .. | 1,026,216 | 1,120,000 | 1,288,000 |
| 17 | Melbourne | Australia | Oceania | 1,801,368 | 2,236,637 | .. | 2,638,692 | 2,697,063 | 2,929,294 |
| 18 | Tauranga | New Zealand | Oceania | 546,521 | 511,343 | .. | 954,006 | 1,085,987 | 1,182,147 |
| 19 | Los Angeles | USA | Northern America | 7,261,000 | 7,831,000 | .. | 8,860,000 | 9,430,000 | 9,460,000 |
| 20 | Vancouver | Canada | Northern America | 2,152,000 | 2,514,000 | .. | 2,920,000 | 3,250,000 | 3,400,000 |
| 21 | Gioia Tauro | Italy | Europe | 2,857,000 | 2,851,000 | .. | 2,797,000 | 2,449,000 | 2,328,000 |
| 22 | Algericas | Spain | Europe | 3,042,000 | 2,810,000 | .. | 4,760,000 | 4,390,000 | 4,770,000 |
| 23 | Rotterdam | Netherlands | Europe | 9,743,000 | 11,145,000 | .. | 12,380,000 | 13,730,000 | 14,510,000 |
| 24 | Felixstowe | UK | Europe | 3,100,000 | 3,400,000 | .. | 4,100,000 | 4,300,000 | 3,850,000 |
| 25 | Hamburg | Germany | Europe | 7,007,000 | 7,900,000 | .. | 8,910,000 | 8,860,000 | 8,730,000 |

| No | Port | Country | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| 26 | Antwerp | Belgium | Europe | 7,309,000 | 8,468,000 | .. | 10,040,000 | 10,450,000 | 11,100,000 |
| 27 | Havre | France | Europe | 2,200,000 | 2,321,082 | .. | 2,478,448 | 2,870,000 | 2,884,000 |
| 28 | Piraeus | Greece | Europe | 665,000 | 513,000 | .. | 3,730,000 | 4,150,000 | 4,910,000 |
| 29 | Gdansk | Poland | Europe | 240,623 | 511,876 | .. | 1,299,373 | 1,580,508 | 1,948,974 |

Source: Elaborated from various sources

### 4.1.2 Port Liner Shipping Connectivity Index (PLSCI)

Port LSCI (PLSCI) reflects a port position in the global liner shipping network. The higher the value indicates better connectivity for the port. The value takes a normalized version each year hence different minimum and maximum range for the yearly index. The data is obtained from the UNCTAD Stat database from 2009—2018 for 29 port samples. Below is the example of the PLSCI data.

Table 4.2 Port Liner Shipping Connectivity Index of 29 Ports Sample from 2009-2018

| No | Port | Country | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Kaohsiung | Taiwan | Asia | 57.18301 | 57.22633 | .. | 72.13272 | 71.80986 | 73.35202 |
| 2 | Hongkong | Hongkong | Asia | 103.4164 | 105.7785 | .. | 104.2091 | 102.5534 | 107.7854 |
| 3 | Shanghai | China | Asia | 105.259 | 107.1724 | .. | 127.8624 | 126.3863 | 133.5827 |
| 4 | Busan | South Korea | Asia | 84.68478 | 84.30152 | .. | 109.8393 | 108.8505 | 111.9636 |
| 5 | Tokyo | Japan | Asia | 45.74087 | 49.11729 | .. | 46.88861 | 45.72172 | 52.86014 |
| 6 | Belawan | Indonesia | Asia | 9.648046 | 9.474928 | .. | 9.194954 | 9.145855 | 13.54561 |
| 7 | Tanjung Priok | Indonesia | Asia | 32.69842 | 31.72605 | .. | 33.42358 | 41.58016 | 44.00715 |
| 8 | Tanjung Perak | Indonesia | Asia | 19.54791 | 20.91171 | .. | 21.7865 | 24.84738 | 27.04077 |
| 9 | Makassar | Indonesia | Asia | 4.777746 | 4.777746 | .. | 8.396884 | 11.1284 | 11.64878 |
| 10 | Singapore | Singapore | Asia | 99.74996 | 108.6878 | .. | 118.3455 | 118.0572 | 128.0958 |

| No | Port | Country | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | Port Klang | Malaysia | Asia | 66.54876 | 69.31036 | .. | 91.44028 | 80.35351 | 83.73712 |
| 12 | Laem Chabang | Thailand | Asia | 34.07132 | 40.41955 | .. | 46.41638 | 43.60027 | 45.80204 |
| 13 | Manila | Philippines | Asia | 21.0189 | 22.24414 | .. | 28.77628 | 28.59767 | 29.28537 |
| 14 | Ho Chi Minh City | Vietnam | Asia | 21.4769 | 22.91641 | .. | 54.40372 | 30.42029 | 27.8499 |
| 15 | Sihanoukville | Cambodia | Asia | 4.513512 | 6.010415 | .. | 9.80594 | 9.62016 | 8.474234 |
| 16 | Yangon | Myanmar | Asia | 4.674169 | 5.96154 | .. | 11.66505 | 9.20507 | 10.18849 |
| 17 | Melbourne | Australia | Oceania | 26.79829 | 25.8867 | .. | 28.78522 | 28.37518 | 28.49344 |
| 18 | Tauranga | New Zealand | Oceania | 17.5937 | 18.45537 | .. | 21.58139 | 34.2544 | 22.13481 |
| 19 | Los Angeles | USA | Northern America | 31.55276 | 30.23195 | .. | 41.56763 | 42.43259 | 42.29334 |
| 20 | Vancouver | Canada | Northern America | 29.69424 | 28.26024 | .. | 31.3246 | 35.82584 | 39.2184 |
| 21 | Gioia Tauro | Italy | Europe | 35.74436 | 29.67635 | .. | 38.64465 | 41.33387 | 41.57671 |
| 22 | Algericas | Spain | Europe | 40.67355 | 44.00874 | .. | 60.33978 | 62.27077 | 63.17768 |
| 23 | Rotterdam | Netherlands | Europe | 86.07434 | 87.60689 | .. | 89.91299 | 88.39582 | 93.70537 |
| 24 | Felixstowe | UK | Europe | 44.40546 | 52.89586 | .. | 57.73624 | 54.24627 | 57.77213 |
| 25 | Hamburg | Germany | Europe | 72.35749 | 71.59072 | .. | 80.56582 | 74.93472 | 77.53443 |
| 26 | Antwerp | Belgium | Europe | 83.60984 | 89.55955 | .. | 92.28646 | 93.4271 | 94.80892 |
| 27 | Havre | France | Europe | 47.36488 | 45.67295 | .. | 61.45246 | 59.28774 | 65.10047 |
| 28 | Piraeus | Greece | Europe | 32.18554 | 28.95457 | .. | 45.06132 | 47.08838 | 54.24614 |
| 29 | Gdansk | Poland | Europe | 5.906151 | 22.67898 | .. | 42.86171 | 42.76354 | 46.951 |

Source: UNCTAD Stat

4.1.3 Liner Shipping Bilateral Connectivity Index (LSBCI)

Similar with the PLSCI, LSBCI data is gathered from UNCTAD Stat database from 2009—2018. The difference lies in the format of the index which corresponds to countries pairwise. For Indonesia ports, the LSBCI takes the same value for each port due to the database available for pairs is in country-level. The value between the same pair remains the same regardless their order (e.g. Indonesia-Singapore has the same value with Singapore-Indonesia). The example of data recapitulation for this index is presented in the following table.

Table 4.3 Liner Shipping Bilateral Connectivity Index of 26 Countries Sample from 2009-2018

| No | Country_i | Country_j | Pair_ij | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Taiwan | Hongkong | Kaohsiung_Hongkong | Asia | 0,6054443 | 0,6161842 | .. | 0,6238064 | 0,6192786 | 0,6112063 |
| 2 | Taiwan | China | Kaohsiung_Shanghai | Asia | 0,6350269 | 0,6532121 | .. | 0,6898447 | 0,6966731 | 0,6900882 |
| 3 | Taiwan | South Korea | Kaohsiung_Busan | Asia | 0,5983444 | 0,6019681 | .. | 0,643283 | 0,6412483 | 0,6374372 |
| 4 | Taiwan | Japan | Kaohsiung_Tokyo | Asia | 0,5656341 | 0,5764312 | .. | 0,5417107 | 0,5432757 | 0,5433604 |
| 5 | Taiwan | Indonesia | Kaohsiung_Belawan | Asia | 0,4088087 | 0,4093471 | .. | 0,360148 | 0,3671089 | 0,3886438 |
| 6 | Taiwan | Indonesia | Kaohsiung_Tanjung Priok | Asia | 0,4088087 | 0,4093471 | .. | 0,360148 | 0,3671089 | 0,3886438 |
| 7 | Taiwan | Indonesia | Kaohsiung_Tanjung Perak | Asia | 0,4088087 | 0,4093471 | .. | 0,360148 | 0,3671089 | 0,3886438 |
| 8 | Taiwan | Indonesia | Kaohsiung_Makassar | Asia | 0,4088087 | 0,4093471 | .. | 0,360148 | 0,3671089 | 0,3886438 |
| 9 | Taiwan | Singapore | Kaohsiung_Singapore | Asia | 0,5475318 | 0,5798023 | .. | 0,6223552 | 0,6112223 | 0,607582 |
| 10 | Taiwan | Malaysia | Kaohsiung_Port Klang | Asia | 0,5255321 | 0,5487307 | .. | 0,5937777 | 0,5669068 | 0,5744857 |
| 11 | Taiwan | Thailand | Kaohsiung_Laem Chabang | Asia | 0,4414304 | 0,4680125 | .. | 0,4758215 | 0,4421994 | 0,4675866 |
| 12 | Taiwan | Philippines | Kaohsiung_Manila | Asia | 0,3413873 | 0,3473494 | .. | 0,3786167 | 0,3903821 | 0,3753563 |
| . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . |
| 460 | Australia | Thailand | Melbourne_Laem Chabang | Oceania | 0,3337258 | 0,3425118 | .. | 0,3722838 | 0,3956712 | 0,4008346 |
| 461 | Australia | Philippines | Melbourne_Manila | Oceania | 0,2772462 | 0,2918527 | .. | 0,3076839 | 0,3127928 | 0,3135507 |
| 462 | Australia | Vietnam | Melbourne_Ho Chi Minh City | Oceania | 0,2997189 | 0,3115103 | .. | 0,3527832 | 0,3412848 | 0,3474973 |
| 463 | Australia | Cambodia | Melbourne_Sihanoukville | Oceania | 0,1919289 | 0,2073642 | .. | 0,2288084 | 0,2293437 | 0,2249355 |
| 464 | Australia | Myanmar | Melbourne_Yangon | Oceania | 0,1793563 | 0,1871883 | .. | 0,2450247 | 0,2383119 | 0,2433892 |
| 465 | Australia | New Zealand | Melbourne_Tauranga | Oceania | 0,4103008 | 0,4063951 | .. | 0,4077031 | 0,4037051 | 0,4070706 |

| No | Country_i | Country_j | Pair_ij | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| 466 | Australia | USA | Melbourne_Los Angeles | Oceania | 0,4306372 | 0,4316546 | .. | 0,440021 | 0,4358184 | 0,4457546 |
| 467 | Australia | Canada | Melbourne_Vancouver | Oceania | 0,362887 | 0,365181 | .. | 0,3651753 | 0,365949 | 0,3666387 |
| 468 | Australia | Italy | Melbourne_Gioia Tauro | Oceania | 0,4172706 | 0,4007871 | .. | 0,4325781 | 0,4349836 | 0,4416718 |
| 469 | Australia | Spain | Melbourne_Algericas | Oceania | 0,4038292 | 0,4034474 | .. | 0,4294684 | 0,4258097 | 0,4377079 |
| 470 | Australia | Netherlands | Melbourne_Rotterdam | Oceania | 0,4103887 | 0,4120802 | .. | 0,4238421 | 0,4292614 | 0,4556641 |
| . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . |
| 505 | USA | Taiwan | Los Angeles_Kaohsiung | Northern America | 0,5523469 | 0,5635707 | .. | 0,5603708 | 0,5433373 | 0,57768 |
| 506 | USA | Hongkong | Los Angeles_Hongkong | Northern America | 0,6130043 | 0,6139706 | .. | 0,6255831 | 0,6103984 | 0,6039085 |
| 507 | USA | China | Los Angeles_Shanghai | Northern America | 0,6331724 | 0,6393127 | .. | 0,6940838 | 0,6886091 | 0,6811891 |
| 508 | USA | South Korea | Los Angeles_Busan | Northern America | 0,5956352 | 0,5875846 | .. | 0,6480687 | 0,6337532 | 0,651045 |
| 509 | USA | Japan | Los Angeles_Tokyo | Northern America | 0,5702714 | 0,5610135 | .. | 0,5970667 | 0,5693122 | 0,5697768 |
| 510 | USA | Indonesia | Los Angeles_Belawan | Northern America | 0,4088035 | 0,3861159 | .. | 0,3355049 | 0,4130214 | 0,4347931 |
| 511 | USA | Indonesia | Los Angeles_Tanjung Priok | Northern America | 0,4088035 | 0,3861159 | .. | 0,3355049 | 0,4130214 | 0,4347931 |
| 512 | USA | Indonesia | Los Angeles_Tanjung Perak | Northern America | 0,4088035 | 0,3861159 | .. | 0,3355049 | 0,4130214 | 0,4347931 |
| 513 | USA | Indonesia | Los Angeles_Makassar | Northern America | 0,4088035 | 0,3861159 | .. | 0,3355049 | 0,4130214 | 0,4347931 |
| 514 | USA | Singapore | Los Angeles_Singapore | Northern America | 0,538111 | 0,5780476 | .. | 0,6602128 | 0,6266875 | 0,6227663 |
| 515 | USA | Malaysia | Los Angeles_Port Klang | Northern America | 0,5470423 | 0,5321588 | .. | 0,6208625 | 0,5860783 | 0,5958231 |
| . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . |
| 574 | Italy | Vietnam | Gioia Tauro_Ho Chi Minh City | Europe | 0,3425104 | 0,3932872 | .. | 0,4931013 | 0,4813662 | 0,4916174 |
| 575 | Italy | Cambodia | Gioia Tauro_Sihanoukville | Europe | 0,2038984 | 0,2190871 | .. | 0,2447858 | 0,2444535 | 0,2368921 |
| 576 | Italy | Myanmar | Gioia Tauro_Yangon | Europe | 0,1891293 | 0,1954776 | .. | 0,2628538 | 0,2565898 | 0,2608992 |
| 577 | Italy | Australia | Gioia Tauro_Melbourne | Europe | 0,4172706 | 0,4007871 | .. | 0,4325781 | 0,4349836 | 0,4416718 |
| 578 | Italy | New Zealand | Gioia Tauro_Tauranga | Europe | 0,3393945 | 0,3203313 | .. | 0,3263309 | 0,3879467 | 0,3214534 |

| No | Country_i | Country_j | Pair_ij | Cluster | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| 579 | Italy | USA | Gioia Tauro_Los Angeles | Europe | 0,5981836 | 0,5677487 | .. | 0,6227916 | 0,6197708 | 0,6365088 |
| 580 | Italy | Canada | Gioia Tauro_Vancouver | Europe | 0,4833678 | 0,4573137 | .. | 0,4723887 | 0,4918074 | 0,4869149 |
| 581 | Italy | Spain | Gioia Tauro_Algericas | Europe | 0,6887427 | 0,6675606 | .. | 0,7337762 | 0,7113284 | 0,6998284 |
| 582 | Italy | Netherlands | Gioia Tauro_Rotterdam | Europe | 0,6042948 | 0,5679222 | .. | 0,5727 | 0,5623416 | 0,5713257 |
| 583 | Italy | UK | Gioia Tauro_Felixstowe | Europe | 0,6300445 | 0,5889229 | .. | 0,6285169 | 0,6253555 | 0,593227 |
| 584 | Italy | Germany | Gioia Tauro_Hamburg | Europe | 0,6127213 | 0,5715615 | .. | 0,6267456 | 0,6172037 | 0,5675721 |
| 585 | Italy | Belgium | Gioia Tauro_Antwerp | Europe | 0,6232326 | 0,5762649 | .. | 0,651145 | 0,6443293 | 0,6103304 |
| 586 | Italy | France | Gioia Tauro_Havre | Europe | 0,6354449 | 0,6304981 | .. | 0,6834531 | 0,6806551 | 0,676415 |
| 587 | Italy | Greece | Gioia Tauro_Piraeus | Europe | 0,5032856 | 0,4889159 | .. | 0,5072991 | 0,529137 | 0,5566543 |
| 588 | Italy | Poland | Gioia Tauro_Gdansk | Europe | 0,2670756 | 0,3718706 | .. | 0,4151848 | 0,4261253 | 0,4179062 |

Source: UNCTAD Stat

### 4.1.4 Multimodal Facility

Multimodal facility represents whether the respected port has any facilities to support multimodal or intermodal connections from or to the port. Typically, ports are connected by one or more railroads as well as highways to support the hinterland transportation. This variable has value of binary 0 or 1. The value is 1 if the port has multimodal facilities in the corresponding year, otherwise it will be valued with 0. The data is obtained from various sources such as, the port authority website, report, database, or masterplan. The recapitulation of the data is presented in the following table.

Table 4.4 Multimodal Facility of 29 Ports from 2009-2018

| No | Port | Country | Cluster | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kaohsiung | Taiwan | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | Hongkong | Hongkong | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | Shanghai | China | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | Busan | South Korea | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | Tokyo | Japan | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | Belawan | Indonesia | Asia | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Tanjung Priok | Indonesia | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 8 | Tanjung Perak | Indonesia | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Makassar | Indonesia | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | Singapore | Singapore | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | Port Klang | Malaysia | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | Laem Chabang | Thailand | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 13 | Manila | Philippines | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Ho Chi Minh City | Vietnam | Asia | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | Sihanoukville | Cambodia | Asia | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 16 | Yangon | Myanmar | Asia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | Melbourne | Australia | Oceania | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | Tauranga | New Zealand | Oceania | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | Los Angeles | USA | Northern America | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | Vancouver | Canada | Northern America | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21 | Gioia Tauro | Italy | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 22 | Algericas | Spain | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | Rotterdam | Netherlands | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 24 | Felixstowe | UK | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| No | Port | Country | Cluster | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Hamburg | Germany | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26 | Antwerp | Belgium | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27 | Havre | France | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28 | Piraeus | Greece | Europe | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29 | Gdansk | Poland | Europe | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Source: Elaborated from various sources

### 4.1.5 Gross Domestic Product (GDP)

Gross Domestic Product or GDP is the nation’s total income and the total expenditure on its output of goods and services. The type of GDP used in this research is nominal GDP or GDP current. It follows the prices applied in the market without any deflator. For Indonesia ports, the GDP used is regional GDP referencing the regions to the area division that has been stated early in this chapter. The rest of the ports follow their country’s GDP. Below is the data of GDP from the samples.

Table 4.5 Gross Domestic Product of 29 Ports Sample 2009-2018 (in million dollars)

| No | Port | Country | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| 1 | Kaohsiung | Taiwan | $ 392,106.00 | $ 446,141.00 | .. | $ 531,357.00 | $ 574,895.00 | $ 589,906.00 |
| 2 | Hongkong | Hongkong | $ 214,046.00 | $ 228,637.00 | .. | $ 320,837.00 | $ 341,244.00 | $ 361,693.00 |
| 3 | Shanghai | China | $ 510,170.00 | $ 608,716.00 | .. | $ 112,332.00 | $ 123,104.00 | $ 138,948.00 |
| 4 | Busan | South Korea | $ 943,941.00 | $ 114,406.00 | .. | $ 150,011.00 | $ 162,390.00 | $ 172,057.00 |
| 5 | Tokyo | Japan | $ 523,138.00 | $ 570,009.00 | .. | $ 492,253.00 | $ 486,686.00 | $ 495,480.00 |
| 6 | Belawan | Indonesia | $ 642,435.00 | $ 102,606.00 | .. | $ 182,736.00 | $ 193,963.00 | $ 209,238.00 |
| 7 | Tanjung Priok | Indonesia | $ 195,867.00 | $ 323,909.00 | .. | $ 617,617.00 | $ 673,295.00 | $ 737,512.00 |

| No | Port | Country | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|
| 8 | Tanjung Perak | Indonesia | $ 128,914.00 | $ 223,175.00 | .. | $ 407,744.00 | $ 442,105.00 | $ 479,387.00 |
| 9 | Makassar | Indonesia | $ 575,787.00 | $ 105,647.00 | .. | $ 180,826.00 | $ 202,857.00 | $ 222,937.00 |
| 10 | Singapore | Singapore | $ 194,152.00 | $ 239,809.00 | .. | $ 318,652.00 | $ 341,863.00 | $ 373,217.00 |
| 11 | Port Klang | Malaysia | $ 202,257.00 | $ 255,016.00 | .. | $ 301,255.00 | $ 318,958.00 | $ 358,581.00 |
| 12 | Laem Chabang | Thailand | $ 281,710.00 | $ 341,104.00 | .. | $ 413,430.00 | $ 456,294.00 | $ 506,514.00 |
| 13 | Manila | Philippines | $ 176,131.00 | $ 208,368.00 | .. | $ 318,627.00 | $ 328,480.00 | $ 346,841.00 |
| 14 | Ho Chi Minh City | Vietnam | $ 106,014.00 | $ 115,931.00 | .. | $ 205,276.00 | $ 223,779.00 | $ 245,213.00 |
| 15 | Sihanoukville | Cambodia | $ 104,018.00 | $ 112,422.00 | .. | $ 200,167.00 | $ 221,772.00 | $ 245,717.00 |
| 16 | Yangon | Myanmar | $ 369,061.00 | $ 495,408.00 | .. | $ 671,842.00 | $ 689,458.00 | $ 761,680.00 |
| 17 | Melbourne | Australia | $ 927,805.00 | $ 114,613.00 | .. | $ 120,884.00 | $ 133,013.00 | $ 143,390.00 |
| 18 | Tauranga | New Zealand | $ 121,357.00 | $ 146,619.00 | .. | $ 188,223.00 | $ 205,415.00 | $ 207,920.00 |
| 19 | Los Angeles | USA | $ 144,489.00 | $ 149,920.00 | .. | $ 187,071.00 | $ 194,853.00 | $ 205,802.00 |
| 20 | Vancouver | Canada | $ 137,115.00 | $ 161,346.00 | .. | $ 152,824.00 | $ 164,987.00 | $ 171,626.00 |
| 21 | Gioia Tauro | Italy | $ 219,124.00 | $ 213,401.00 | .. | $ 187,579.00 | $ 196,179.00 | $ 208,576.00 |
| 22 | Algericas | Spain | $ 148,558.00 | $ 142,072.00 | .. | $ 123,207.00 | $ 131,255.00 | $ 141,973.00 |
| 23 | Rotterdam | Netherlands | $ 868,077.00 | $ 846,554.00 | .. | $ 783,528.00 | $ 833,869.00 | $ 914,104.00 |
| 24 | Felixstowe | UK | $ 241,090.00 | $ 247,524.00 | .. | $ 269,428.00 | $ 266,622.00 | $ 286,066.00 |
| 25 | Hamburg | Germany | $ 339,779.00 | $ 339,635.00 | .. | $ 346,679.00 | $ 366,580.00 | $ 394,954.00 |
| 26 | Antwerp | Belgium | $ 481,345.00 | $ 480,951.00 | .. | $ 475,900.00 | $ 503,788.00 | $ 542,685.00 |
| 27 | Havre | France | $ 269,022.00 | $ 264,260.00 | .. | $ 247,128.00 | $ 259,515.00 | $ 278,786.00 |
| 28 | Piraeus | Greece | $ 330,000.00 | $ 299,361.00 | .. | $ 195,222.00 | $ 203,588.00 | $ 218,138.00 |
| 29 | Gdansk | Poland | $ 439,793.00 | $ 479,321.00 | .. | $ 472,037.00 | $ 526,380.00 | $ 587,114.00 |
| 30 | WORLD | WORLD | $ 603,955.00 | $ 661,131.00 | .. | $ 763,357.00 | $ 812,291.00 | $ 864,089.00 |

Source: World Bank

### 4.1.6 Exchange Rate Volatility

Exchange rate alone is a common determinant for trade-related studies. However, in order to accommodate the time-varying characteristics, this research uses exchange rate volatility instead. The formula used here is based on Tenreyro (2006) as shown in the following line.

$$ERvol_{ijt} = std.dev.\left[ln\left(ER_{ijt,m}\right) - ln\left(ER_{ijt,m-1}\right)\right] \quad (4.1)$$

where

$ERvol_{ijt}$ : exchange rate volatility between country i and j in year t

$ER_{ijt,m}$ : nominal exchange rate between country i's currency against country j in month m and year t

From the formula above, the exchange rate data for each country is required before the calculation of volatility can be conducted. Hence the data of exchange rates from the country samples are collected. To maintain the consistency of the exchange rate data, the values taken are the conversion value of US Dollar to the respected countries' currency by the end of each month. Below is the example of the monthly exchange rate data from December 2008 until December 2018.

Table 4.6 Example of Exchange Rate Data from 2009-2018

| Year | Month | USD to currency | Currency | Code | Country | ln(Ert/Ert-1) |
|---|---|---|---|---|---|---|
| 2008 | Dec | 33,149565 | New Taiwan Dollar | TWD | Taiwan | |
| 2009 | Jan | 33,339168 | New Taiwan Dollar | TWD | Taiwan | 0,005703328 |
| 2009 | Feb | 34,211766 | New Taiwan Dollar | TWD | Taiwan | 0,025836698 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 2009 | Oct | 32,306774 | New Taiwan Dollar | TWD | Taiwan | -0,008626287 |
| 2009 | Nov | 32,366 | New Taiwan Dollar | TWD | Taiwan | 0,001831559 |
| 2009 | Dec | 32,240968 | New Taiwan Dollar | TWD | Taiwan | -0,003870547 |
| 2010 | Jan | 31,744355 | New Taiwan Dollar | TWD | Taiwan | -0,015523028 |
| 2010 | Feb | 31,982143 | New Taiwan Dollar | TWD | Taiwan | 0,007462802 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 2010 | Oct | 30,875032 | New Taiwan Dollar | TWD | Taiwan | -0,027136158 |
| 2010 | Nov | 30,332053 | New Taiwan Dollar | TWD | Taiwan | -0,017742823 |
| 2010 | Dec | 30,008548 | New Taiwan Dollar | TWD | Taiwan | -0,010722734 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |

| Year | Month | USD to currency | Currency | Code | Country | ln(Ert/Ert-1) |
|---|---|---|---|---|---|---|
| 2016 | Jan | 33,397452 | New Taiwan Dollar | TWD | Taiwan | 0,017323585 |
| 2016 | Feb | 33,290845 | New Taiwan Dollar | TWD | Taiwan | -0,003197175 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 2016 | Oct | 31,583274 | New Taiwan Dollar | TWD | Taiwan | 0,002166687 |
| 2016 | Nov | 31,78135 | New Taiwan Dollar | TWD | Taiwan | 0,006251963 |
| 2016 | Dec | 32,031863 | New Taiwan Dollar | TWD | Taiwan | 0,007851486 |
| 2017 | Jan | 31,695597 | New Taiwan Dollar | TWD | Taiwan | -0,010553351 |
| 2017 | Feb | 30,862157 | New Taiwan Dollar | TWD | Taiwan | -0,026647035 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 2017 | Oct | 30,264933 | New Taiwan Dollar | TWD | Taiwan | 0,0042134 |
| 2017 | Nov | 30,08991 | New Taiwan Dollar | TWD | Taiwan | -0,005799816 |
| 2017 | Dec | 29,942822 | New Taiwan Dollar | TWD | Taiwan | -0,00490027 |
| 2018 | Jan | 29,426469 | New Taiwan Dollar | TWD | Taiwan | -0,017395054 |
| 2018 | Feb | 29,252555 | New Taiwan Dollar | TWD | Taiwan | -0,005927655 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 2018 | Oct | 30,909758 | New Taiwan Dollar | TWD | Taiwan | 0,006407073 |
| 2018 | Nov | 30,81375 | New Taiwan Dollar | TWD | Taiwan | -0,003110908 |
| 2018 | Dec | 30,797097 | New Taiwan Dollar | TWD | Taiwan | -0,000540587 |

Source: Elaborated from various sources

After all the currencies have been recapitulated, the calculation process of exchange rates volatility can be proceeded. Below is the calculation example for exchange rate volatility of New Taiwan Dollar in 2009.

$$ERvol_{ijt} = std.dev.\left[ln\left(ER_{ijt,m}/ER_{ijt,m-1}\right)\right]$$

$$ERvol_{ijt} = std.dev.[ln(33.34/33.15) + ln(34.21/34.39) + \cdots + ln(32.24/32.37)] = 0.0131$$

It can be seen that the volatility of New Taiwan Dollar in 2009 is 0.0131. This variable takes the value range of 0 to infinity. Similar calculations are conducted to obtain the volatility for the rest of the currencies. Below is the example of exchange rate volatility recap from the 26 countries observed.

Table 4.7 Exchange Rate Volatility Data of 26 Countries Sample from 2009-2018

| No | Region | Port | Country | Cluster | Code | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Eastern Asia | Kaohsiung | Taiwan | Asia | TWD | 0,0130519 | 0,0116841 | .. | 0,0107588 | 0,0085354 | 0,0092262 |
| 2 | | Hongkong | Hongkong | Asia | HKD | 0,0003207 | 0,0013502 | .. | 0,0014530 | 0,0009664 | 0,0010583 |
| 3 | | Shanghai | China | Asia | CNY | 0,0010038 | 0,0038875 | .. | 0,0086692 | 0,0071272 | 0,0166643 |
| 4 | | Busan | South Korea | Asia | KRW | 0,0373984 | 0,0254776 | .. | 0,0229163 | 0,0129904 | 0,0116078 |
| 5 | | Tokyo | Japan | Asia | JPY | 0,0245548 | 0,0204358 | .. | 0,0321894 | 0,0157068 | 0,0147441 |
| 6 | ASEAN | Belawan | Indonesia | Asia | IDR | 0,0332762 | 0,0120472 | .. | 0,0155868 | 0,0053361 | 0,0175955 |
| 7 | | Tanjung Priok | Indonesia | Asia | IDR | 0,0332762 | 0,0120472 | .. | 0,0155868 | 0,0053361 | 0,0175955 |
| 8 | | Tanjung Perak | Indonesia | Asia | IDR | 0,0332762 | 0,0120472 | .. | 0,0155868 | 0,0053361 | 0,0175955 |
| 9 | | Makassar | Indonesia | Asia | IDR | 0,0332762 | 0,0120472 | .. | 0,0155868 | 0,0053361 | 0,0175955 |
| 10 | | Singapore | Singapore | Asia | SGD | 0,0140168 | 0,0112676 | .. | 0,0160041 | 0,0048653 | 0,0088465 |
| 11 | | Port Klang | Malaysia | Asia | MYR | 0,0142241 | 0,0152876 | .. | 0,0277130 | 0,0087004 | 0,0132840 |
| 12 | | Laem Chabang | Thailand | Asia | THB | 0,0102540 | 0,0130661 | .. | 0,0089110 | 0,0052266 | 0,0146090 |
| 13 | | Manila | Philippines | Asia | PHP | 0,0126202 | 0,0158088 | .. | 0,0130862 | 0,0077944 | 0,0115294 |
| 14 | | Ho Chi Minh City | Vietnam | Asia | VND | 0,0104482 | 0,0107880 | .. | 0,0043044 | 0,0026900 | 0,0037119 |
| 15 | | Sihanoukville | Cambodia | Asia | KHR | 0,0074276 | 0,0094569 | .. | 0,0058942 | 0,0048090 | 0,0064905 |
| 16 | | Yangon | Myanmar | Asia | MMK | 0,0000700 | 0,0000000 | .. | 0,0263292 | 0,0042839 | 0,0236790 |
| 17 | Oceania | Melbourne | Australia | Oceania | AUD | 0,0342926 | 0,0308438 | .. | 0,0264094 | 0,0187872 | 0,0170066 |
| 18 | | Tauranga | New Zealand | Oceania | NZD | 0,0422447 | 0,0237492 | .. | 0,0185742 | 0,0212075 | 0,0228443 |
| 19 | Northern America | Los Angeles | USA | Northern America | USD | 0,0000000 | 0,0000000 | .. | 0,0000000 | 0,0000000 | 0,0000000 |
| 20 | | Vancouver | Canada | Northern America | CAD | 0,0233269 | 0,0163326 | .. | 0,0217455 | 0,0209411 | 0,0153348 |
| 21 | Europe | Gioia Tauro | Italy | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |
| 22 | | Algericas | Spain | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |

| No | Region | Port | Country | Cluster | Code | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | | Rotterdam | Netherlands | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |
| 24 | | Felixstowe | UK | Europe | GBP | 0,0286292 | 0,0259413 | .. | 0,0295674 | 0,0146861 | 0,0192603 |
| 25 | | Hamburg | Germany | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |
| 26 | | Antwerp | Belgium | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |
| 27 | | Havre | France | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |
| 28 | | Piraeus | Greece | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |
| 29 | | Gdansk | Poland | Europe | EUR | 0,0213671 | 0,0361886 | .. | 0,0152426 | 0,0130039 | 0,0166445 |

### 4.1.7 Bilateral Trade Intensity Index (TII)

Bilateral trade intensity index indicates “whether the value of trade between two countries is greater or smaller than would be expected on the basis of their importance in world trade” (World Bank, n.d.). The trade intensity index used in this research is adopting from Deardoff’s formula as follow.

$$Bilateral\ Trade\ Intensity_{ijt} = \frac{Exp_{ijt} + Imp_{ijt}}{GDP_{it} GDP_{jt}} \times \frac{GDP_{wt}}{2} \qquad (4.2)$$

where

$Exp_{ijt}$ : the nominal exports value from country i to country j (where the ports are located) at time t

$Imp_{ijt}$ : the nominal imports value of country i from country j (where the ports are located) at time t

$GDP_{it}, GDP_{jt}$ : the GDP of country i and j at time t respectively

$GDP_{wt}$ : the world’s GDP at time t

From the formula, the data required consists of GDP for each country, world’s GDP, and export import data between country pairs. GDP requirement can be covered by the previously collected data. The data of nominal export import value can be found in UNCTAD Stat under the category of merchandise trade matrix – exports/imports. The merchandise category is considered suitable to represent the container throughput since merchandises are commonly containerized during shipping. The example data of exports imports between country pairs can be seen in the following tables.

Table 4.8 Export Data of 26 Countries from 2009-2018 (in thousand dollars)

| No | Country_i | Country_j | Pair_ij | 2009 | .. | 2018 |
|---|---|---|---|---|---|---|
| 1 | Taiwan | Hongkong | Kaohsiung_Hongkong | $ 29,428,629.62 | .. | $ 44,750,427.11 |
| 2 | Taiwan | China | Kaohsiung_Shanghai | $ 54,163,156.88 | .. | $ 92,161,052.73 |
| 3 | Taiwan | South Korea | Kaohsiung_Busan | $ 7,296,067.00 | .. | $ 15,557,934.56 |
| 4 | Taiwan | Japan | Kaohsiung_Tokyo | $ 14,497,975.51 | .. | $ 22,648,174.07 |
| 5 | Taiwan | Indonesia | Kaohsiung_Belawan | $ 3,217,034.89 | .. | $ 3,406,398.52 |
| 6 | Taiwan | Indonesia | Kaohsiung_Tanjung Priok | $ 3,217,034.89 | .. | $ 3,406,398.52 |
| 7 | Australia | Taiwan | Melbourne_Kaohsiung | $ 5,093,460.46 | .. | $ 7,812,953.62 |
| 8 | Australia | Hongkong | Melbourne_Hongkong | $ 2,256,754.05 | .. | $ 7,676,459.24 |
| 9 | Australia | China | Melbourne_Shanghai | $ 33,389,244.43 | .. | $ 87,726,224.73 |
| 10 | Australia | South Korea | Melbourne_Busan | $ 12,281,988.99 | .. | $ 17,745,603.69 |
| 11 | Australia | Japan | Melbourne_Tokyo | $ 30,014,166.31 | .. | $ 41,355,759.25 |
| 12 | Australia | Indonesia | Melbourne_Belawan | $ 3,250,128.88 | .. | $ 4,796,360.17 |
| 13 | Australia | Indonesia | Melbourne_Tanjung Priok | $ 3,250,128.88 | .. | $ 4,796,360.17 |
| 14 | USA | Taiwan | Los Angeles_Kaohsiung | $ 18,432,345.89 | .. | $ 30,560,207.94 |
| 15 | USA | Hongkong | Los Angeles_Hongkong | $ 21,117,126.29 | .. | $ 37,284,153.81 |
| 16 | USA | China | Los Angeles_Shanghai | $ 69,575,613.27 | .. | $ 120,147,865.72 |
| 17 | USA | South Korea | Los Angeles_Busan | $ 28,639,747.63 | .. | $ 56,504,532.09 |
| 18 | USA | Japan | Los Angeles_Tokyo | $ 51,178,320.34 | .. | $ 75,226,085.62 |
| 19 | USA | Indonesia | Los Angeles_Belawan | $ 5,106,426.28 | .. | $ 8,171,546.17 |
| 20 | USA | Indonesia | Los Angeles_Tanjung Priok | $ 5,106,426.28 | .. | $ 8,171,546.17 |
| 21 | USA | Indonesia | Los Angeles_Tanjung Perak | $ 5,106,426.28 | .. | $ 8,171,546.17 |
| . | . | . | . | . | .. | . |
| . | . | . | . | . | .. | . |
| 808 | Italy | Taiwan | Gioia Tauro_Kaohsiung | $ 1,137,638.10 | .. | $ 1,670,913.72 |

| No | Country_i | Country_j | Pair_ij | 2009 | .. | 2018 |
|---|---|---|---|---|---|---|
| 809 | Italy | Hongkong | Gioia Tauro_Hongkong | $ 3,758,041.87 | .. | $ 7,048,707.22 |
| 810 | Italy | China | Gioia Tauro_Shanghai | $ 9,205,866.66 | .. | $ 15,486,004.71 |
| 811 | Italy | South Korea | Gioia Tauro_Busan | $ 2,998,192.13 | .. | $ 5,339,386.47 |
| 812 | Italy | Japan | Gioia Tauro_Tokyo | $ 5,145,594.03 | .. | $ 7,627,484.30 |

Source: UNCTAD Stat

Table 4.9 Import Data of 26 Countries from 2009-2018 (in thousand dollars)

| No | Country_i | Country_j | Pair_ij | 2009 | .. | 2018 |
|---|---|---|---|---|---|---|
| 1 | Taiwan | Hongkong | Kaohsiung_Hongkong | $ 1,122,728.32 | .. | $ 1,732,186.36 |
| 2 | Taiwan | China | Kaohsiung_Shanghai | $ 24,490,503.22 | .. | $ 56,837,502.15 |
| 3 | Taiwan | South Korea | Kaohsiung_Busan | $ 10,529,918.91 | .. | $ 18,850,474.38 |
| 4 | Taiwan | Japan | Kaohsiung_Tokyo | $ 36,312,868.08 | .. | $ 49,214,139.80 |
| 5 | Taiwan | Indonesia | Kaohsiung_Belawan | $ 5,214,628.12 | .. | $ 5,807,202.07 |
| 6 | Taiwan | Indonesia | Kaohsiung_Tanjung Priok | $ 5,214,628.12 | .. | $ 5,807,202.07 |
| 7 | Australia | Taiwan | Melbourne_Kaohsiung | $ 2,444,269.04 | .. | $ 3,631,909.89 |
| 8 | Australia | Hongkong | Melbourne_Hongkong | $ 985,978.92 | .. | $ 768,004.25 |
| 9 | Australia | China | Melbourne_Shanghai | $ 29,211,722.24 | .. | $ 57,699,421.91 |
| 10 | Australia | South Korea | Melbourne_Busan | $ 5,293,359.76 | .. | $ 10,182,484.35 |
| 11 | Australia | Japan | Melbourne_Tokyo | $ 13,476,040.13 | .. | $ 17,351,100.06 |
| 12 | Australia | Indonesia | Melbourne_Belawan | $ 3,654,319.36 | .. | $ 3,846,286.26 |
| 13 | Australia | Indonesia | Melbourne_Tanjung Priok | $ 3,654,319.36 | .. | $ 3,846,286.26 |
| 14 | USA | Taiwan | Los Angeles_Kaohsiung | $ 29,349,133.09 | .. | $ 47,261,400.46 |
| 15 | USA | Hongkong | Los Angeles_Hongkong | $ 3,682,878.12 | .. | $ 6,430,502.38 |
| 16 | USA | China | Los Angeles_Shanghai | $309,530,233.20 | .. | $ 563,203,119.54 |

| No | Country_i | Country_j | Pair_ij | 2009 | .. | 2018 |
|---|---|---|---|---|---|---|
| 17 | USA | South Korea | Los Angeles_Busan | $ 40,543,872.27 | .. | $ 76,200,587.12 |
| 18 | USA | Japan | Los Angeles_Tokyo | $ 98,401,031.29 | .. | $ 145,902,252.54 |
| 19 | USA | Indonesia | Los Angeles_Belawan | $ 13,650,990.75 | .. | $ 21,831,954.48 |
| 20 | USA | Indonesia | Los Angeles_Tanjung Priok | $ 13,650,990.75 | .. | $ 21,831,954.48 |
| 21 | USA | Indonesia | Los Angeles_Tanjung Perak | $ 13,650,990.75 | .. | $ 21,831,954.48 |
| . | . | . | . | . | .. | . |
| . | . | . | . | . | .. | . |
| 808 | Italy | Taiwan | Gioia Tauro_Kaohsiung | $ 1,957,696.95 | .. | $ 2,475,733.33 |
| 809 | Italy | Hongkong | Gioia Tauro_Hongkong | $ 432,693.72 | .. | $ 358,596.34 |
| 810 | Italy | China | Gioia Tauro_Shanghai | $ 26,914,449.80 | .. | $ 36,261,008.58 |
| 811 | Italy | South Korea | Gioia Tauro_Busan | $ 3,009,060.24 | .. | $ 4,789,010.06 |
| 812 | Italy | Japan | Gioia Tauro_Tokyo | $ 5,433,761.15 | .. | $ 4,442,704.38 |

Source: UNCTAD Stat

After collecting all the prerequisites, the calculation of bilateral trade intensity index can be processed. If compared with the LSBCI the index of bilateral TII has different means for different order because the level of trade activity is different as well (e.g. TII for Taiwan-China is different with China-Taiwan) The calculation example of bilateral TII for Taiwan-China in 2009 is as shown in the following lines.

$$Bilateral\ Trade\ Intensity_{ijt} = \frac{Exp_{ijt} + Imp_{ijt}}{GDP_{it}GDP_{jt}} \times \frac{GDP_{wt}}{2}$$

$$Bilateral\ Trade\ Intensity_{ijt} = \frac{(10^3)(\$54{,}163{,}156.88 + \$24{,}490{,}503.22)}{(10^6)(\$392{,}106)(\$5{,}101{,}702)} \times \frac{(10^6)(\$60{,}395{,}540)}{2}$$

$$Bilateral\ Trade\ Intensity_{ijt} = 1.187$$

It can be seen that the bilateral TII between Taiwan and China in 2009 is 1.187. The range of this index is from 0 to infinity, similar with exchange rate volatility. Similar calculations are conducted to obtain the bilateral TII for the rest of the country/port pairs. Below is the example of bilateral TII recap from the 29 ports/26 countries observed.

Table 4.10 Bilateral Trade Intensity Index of 26 Countries from 2009-2018

| No | Country_i | Country_j | Pair_ij | 2009 | .. | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| 1 | Taiwan | Hongkong | Kaohsiung_Hongkong | 10.99244 | .. | 8.85935 | 9.41231 |
| 2 | Taiwan | China | Kaohsiung_Shanghai | 1.18734 | .. | 0.79850 | 0.78537 |
| 3 | Taiwan | South Korea | Kaohsiung_Busan | 1.45439 | .. | 1.37805 | 1.46466 |
| 4 | Taiwan | Japan | Kaohsiung_Tokyo | 0.74802 | .. | 0.91184 | 1.06223 |
| 5 | Taiwan | Indonesia | Kaohsiung_Belawan | 10.10776 | .. | 2.95303 | 3.22502 |
| 6 | Taiwan | Indonesia | Kaohsiung_Tanjung Priok | 10.10776 | .. | 2.95303 | 3.22502 |
| 7 | Australia | Taiwan | Melbourne_Kaohsiung | 10.10776 | .. | 2.95303 | 3.22502 |
| 8 | Australia | Hongkong | Melbourne_Hongkong | 10.10776 | .. | 2.95303 | 3.22502 |
| 9 | Australia | China | Melbourne_Shanghai | 5.31654 | .. | 5.45584 | 5.68409 |
| 10 | Australia | South Korea | Melbourne_Busan | 3.33027 | .. | 3.89159 | 3.78112 |
| 11 | Australia | Japan | Melbourne_Tokyo | 1.78025 | .. | 1.66575 | 1.69357 |
| 12 | Australia | Indonesia | Melbourne_Belawan | 2.64281 | .. | 2.58018 | 2.71335 |
| 13 | Australia | Indonesia | Melbourne_Tanjung Priok | 5.02255 | .. | 4.30493 | 4.42216 |
| 14 | USA | Taiwan | Los Angeles_Kaohsiung | 2.48892 | .. | 2.32100 | 2.45094 |
| 15 | USA | Hongkong | Los Angeles_Hongkong | 0.28561 | .. | 0.30349 | 0.31498 |

| No | Country_i | Country_j | Pair_ij | 2009 | .. | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| 16 | USA | China | Los Angeles_Shanghai | 0.69119 | .. | 0.60222 | 0.62278 |
| 17 | USA | South Korea | Los Angeles_Busan | 0.48105 | .. | 0.45029 | 0.52804 |
| 18 | USA | Japan | Los Angeles_Tokyo | 0.22363 | .. | 0.24505 | 0.26764 |
| 19 | USA | Indonesia | Los Angeles_Belawan | 0.14622 | .. | 0.16461 | 0.17897 |
| 20 | USA | Indonesia | Los Angeles_Tanjung Priok | 0.12720 | .. | 0.16808 | 0.17823 |
| 21 | USA | Indonesia | Los Angeles_Tanjung Perak | 0.08069 | .. | 0.09407 | 0.10041 |
| . | . | . | . | . | .. | . | . |
| . | . | . | . | . | .. | . | . |
| 808 | Italy | Taiwan | Gioia Tauro_Kaohsiung | 0.37563 | .. | 0.55472 | 0.58326 |
| 809 | Italy | Hongkong | Gioia Tauro_Hongkong | 1.39635 | .. | 2.30852 | 2.49014 |
| 810 | Italy | China | Gioia Tauro_Shanghai | 0.96410 | .. | 1.57474 | 1.72863 |
| 811 | Italy | South Korea | Gioia Tauro_Busan | 0.41837 | .. | 0.61660 | 0.64111 |
| 812 | Italy | Japan | Gioia Tauro_Tokyo | 0.22627 | .. | 0.51454 | 0.54535 |

#### 4.1.8 Free-Trade Agreements

A free-trade agreement, in simplified manner, means when the members of a preferential trading can go as far as to eliminate all tariffs and quantitative import restrictions among themselves, it can be said as a free-trade agreement (Frankel, 1997). This variable is represented as dummy variable with binary value 0 or 1. The value is 1 if the country pair has free-trade agreements in the corresponding year, otherwise it will be valued with 0. The data is obtained from various sources such as, the trade bloc (e.g. European Union, ASEAN, etc) official report or database, as well as from the official government report and database (e.g. Ministry of Trades). The recapitulation of the data is presented in the following table

Table 4.11 Free-Trade Agreements Dummy of 26 Countries Sample from 2009-2018

| No | Country i | Country_j | Pair_ij | Cluster_i | Cluster_j | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Taiwan | Hongkong | Kaohsiung_Hongkong | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 2 | Taiwan | China | Kaohsiung_Shanghai | Asia | Asia | 0 | 1 | .. | 1 | 1 | 1 |
| 3 | Taiwan | South Korea | Kaohsiung_Busan | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 4 | Taiwan | Japan | Kaohsiung_Tokyo | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 5 | Taiwan | Indonesia | Kaohsiung_Belawan | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 6 | Taiwan | Indonesia | Kaohsiung_Tanjung Priok | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 7 | Taiwan | Indonesia | Kaohsiung_Tanjung Perak | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 8 | Taiwan | Indonesia | Kaohsiung_Makassar | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 9 | Taiwan | Singapore | Kaohsiung_Singapore | Asia | Asia | 0 | 0 | .. | 1 | 1 | 1 |
| 10 | Taiwan | Malaysia | Kaohsiung_Port Klang | Asia | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . |
| 449 | Australia | Taiwan | Melbourne_Kaohsiung | Oceania | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 450 | Australia | Hongkong | Melbourne_Hongkong | Oceania | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 451 | Australia | China | Melbourne_Shanghai | Oceania | Asia | 0 | 0 | .. | 1 | 1 | 1 |
| 452 | Australia | South Korea | Melbourne_Busan | Oceania | Asia | 0 | 0 | .. | 1 | 1 | 1 |
| 453 | Australia | Japan | Melbourne_Tokyo | Oceania | Asia | 0 | 0 | .. | 1 | 1 | 1 |
| 454 | Australia | Indonesia | Melbourne_Belawan | Oceania | Asia | 0 | 1 | .. | 1 | 1 | 1 |
| 455 | Australia | Indonesia | Melbourne_Tanjung Priok | Oceania | Asia | 0 | 1 | .. | 1 | 1 | 1 |
| 456 | Australia | Indonesia | Melbourne_Tanjung Perak | Oceania | Asia | 0 | 1 | .. | 1 | 1 | 1 |
| 457 | Australia | Indonesia | Melbourne_Makassar | Oceania | Asia | 0 | 1 | .. | 1 | 1 | 1 |
| 458 | Australia | Singapore | Melbourne_Singapore | Oceania | Asia | 1 | 1 | .. | 1 | 1 | 1 |
| 459 | Australia | Malaysia | Melbourne_Port Klang | Oceania | Asia | 0 | 1 | .. | 1 | 1 | 1 |
| 460 | Australia | Thailand | Melbourne_Laem Chabang | Oceania | Asia | 1 | 1 | .. | 1 | 1 | 1 |

| No | Country i | Country_j | Pair_ij | Cluster_i | Cluster_j | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . |
| 505 | USA | Taiwan | Los Angeles_Kaohsiung | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 506 | USA | Hongkong | Los Angeles_Hongkong | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 507 | USA | China | Los Angeles_Shanghai | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 508 | USA | South Korea | Los Angeles_Busan | Northern America | Asia | 0 | 0 | .. | 1 | 1 | 1 |
| 509 | USA | Japan | Los Angeles_Tokyo | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 510 | USA | Indonesia | Los Angeles_Belawan | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 511 | USA | Indonesia | Los Angeles_Tanjung Priok | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 512 | USA | Indonesia | Los Angeles_Tanjung Perak | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 513 | USA | Indonesia | Los Angeles_Makassar | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 514 | USA | Singapore | Los Angeles_Singapore | Northern America | Asia | 1 | 1 | .. | 1 | 1 | 1 |
| 515 | USA | Malaysia | Los Angeles_Port Klang | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 516 | USA | Thailand | Los Angeles_Laem Chabang | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 517 | USA | Philippines | Los Angeles_Manila | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 518 | USA | Vietnam | Los Angeles_Ho Chi Minh City | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 519 | USA | Cambodia | Los Angeles_Sihanoukville | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 520 | USA | Myanmar | Los Angeles_Yangon | Northern America | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . |
| 570 | Italy | Singapore | Gioia Tauro_Singapore | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 571 | Italy | Malaysia | Gioia Tauro_Port Klang | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 572 | Italy | Thailand | Gioia Tauro_Laem Chabang | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 573 | Italy | Philippines | Gioia Tauro_Manila | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 574 | Italy | Vietnam | Gioia Tauro_Ho Chi Minh City | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |

| No | Country i | Country_j | Pair_ij | Cluster_i | Cluster_j | 2009 | 2010 | .. | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 575 | Italy | Cambodia | Gioia Tauro_Sihanoukville | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 576 | Italy | Myanmar | Gioia Tauro_Yangon | Europe | Asia | 0 | 0 | .. | 0 | 0 | 0 |
| 577 | Italy | Australia | Gioia Tauro_Melbourne | Europe | Oceania | 0 | 0 | .. | 0 | 0 | 0 |
| 578 | Italy | New Zealand | Gioia Tauro_Tauranga | Europe | Oceania | 0 | 0 | .. | 0 | 0 | 0 |
| 579 | Italy | USA | Gioia Tauro_Los Angeles | Europe | Northern America | 0 | 0 | .. | 0 | 0 | 0 |
| 580 | Italy | Canada | Gioia Tauro_Vancouver | Europe | Northern America | 0 | 0 | .. | 0 | 1 | 1 |
| 581 | Italy | Spain | Gioia Tauro_Algericas | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 582 | Italy | Netherlands | Gioia Tauro_Rotterdam | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 583 | Italy | UK | Gioia Tauro_Felixstowe | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 584 | Italy | Germany | Gioia Tauro_Hamburg | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 585 | Italy | Belgium | Gioia Tauro_Antwerp | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 586 | Italy | France | Gioia Tauro_Havre | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 587 | Italy | Greece | Gioia Tauro_Piraeus | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |
| 588 | Italy | Poland | Gioia Tauro_Gdansk | Europe | Europe | 1 | 1 | .. | 1 | 1 | 1 |

Source: Elaborated from various sources

## 4.2 Panel Regression Modelling

This subchapter contains the walkthrough and explanation of how both scenarios proposed in the previous chapter will be estimated by using panel regression estimation modelling. This method is chosen as it can represent the econometrics analysis in which the economic theory or phenomenon is analyzed through statistics or mathematical model. The data prepared as the previous subchapter holds is processed with the help of EViews 10 software. The processes mentioned include regression modelling, model selection, assumption testing, and model testing with latter three will have their own subchapter right after this subchapter.

### 4.2.1 Scenario 1: Port as Individuals

The first scenario is rather straightforward by treating the sample as individuals as it already is. There are 29 ports/26 countries included as samples in this scenario. Hence, multiplied with the number of periods included meaning that the number of observations for scenario 1 is 290 observations. Meanwhile, the explanatory variables are consisted of four variables in total: two variables from maritime logistics aspects (PLSCI and MM) and other two variables representing macroeconomics (ln GDP and ER). For both scenarios, the data is estimated with fixed effects model (FEM) and random effects model (REM). In this research, the effects tested into the model are cross-sections only which in this first scenario, the cross-section effects are the port effects. The result from FEM with cross-section effects can be seen in the following table.

Table 4.12 Scenario 1: Fixed Effects Model (FEM) Result

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| Methods: Fixed effects (cross-sections) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | 6.5391 | 1.0893 | 6.0031 | 0.0000 |
| PLSCI | 0.0238 | 0.0034 | 7.0315 | 0.0000 |
| MM | 0.0942 | 0.1165 | 0.8089 | 0.4193 |
| ln GDP | 0.2725 | 0.0407 | 6.6912 | 0.0000 |
| ER | -0.0496 | 0.0992 | -0.4997 | 0.6177 |

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| Methods: Fixed effects (cross-sections) | | | | |
| | | | | |
| R-squared | 0.9751 | | | |
| F-statistic | 314.0153 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.6111 | | | |
| | | | | |
| Num. of cross-sections | 29 | | | |
| Num. of periods | 10 | | | |
| N | 290 | | | |
| | | | | |
| ***Port effects*** | | | | |
| Algericas | -0.2264 | | | |
| Antwerp | -0.0619 | | | |
| Belawan | -0.1006 | | | |
| Busan | 0.0437 | | | |
| Felixstowe | -0.5292 | | | |
| Gdansk | -1.0469 | | | |
| Gioia Tauro | -0.4779 | | | |
| Hamburg | -0.3289 | | | |
| Havre | -1.0093 | | | |
| Ho Chi Minh City | 1.0541 | | | |
| Hongkong | 0.5403 | | | |
| Kaohsiung | 0.5932 | | | |
| Laem Chabang | 0.8341 | | | |
| Los Angeles | 0.1153 | | | |
| Makassar | -0.5912 | | | |
| Manila | 0.8645 | | | |
| Melbourne | -0.1630 | | | |
| Piraeus | -0.1002 | | | |
| Port Klang | 0.4526 | | | |
| Rotterdam | 0.0913 | | | |
| Shanghai | -0.2918 | | | |
| Sihanoukville | -0.4917 | | | |
| Singapore | 0.7965 | | | |
| Tanjung Perak | 0.6686 | | | |
| Tanjung Priok | 0.8285 | | | |
| Tauranga | -0.6245 | | | |
| Tokyo | -0.4367 | | | |
| Vancouver | -0.2012 | | | |
| Yangon | -0.2015 | | | |

From the table above, it can be seen that the variable of multimodal facility (MM) and exchange rate volatility (ER) are insignificant which can be implied from the probability (p-value) that exceeds 5% significance level or α. The p-value is the evidence to against a null hypothesis, the smaller the value, the stronger evidence to reject the null hypothesis. With significance level of 5% or 0.05, it means that there is only a room of 5% chance for the result to be random or happened by chance. In this case, the MM and ER variables show 42% and 62% chance of the results could be random which exceed far from the point of rejection that has been set which is 5%. However, MM variable should have been a significant variable towards container throughput which means type 2 error (false negative; accepting a false hypothesis) is found here. For the random effects model, the software running results the estimation as recapitulated in the following table.

Table 4.13 Scenario 1: Random Effects Model (REM) Result

| **Explanatory variables** | **Coefficients** | **Std. Error** | **t-Statistic** | **Probability** |
|---|---|---|---|---|
| Methods: Random effects (cross-sections) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | 7.9591 | 0.9777 | 8.1408 | 0.0000 |
| PLSCI | 0.0259 | 0.0038 | 6.8209 | 0.0000 |
| MM | 0.0462 | 0.1099 | 0.4198 | 0.6749 |
| ln GDP | 0.2176 | 0.0265 | 8.2028 | 0.0000 |
| ER | -0.0457 | 0.1260 | -0.3630 | 0.7169 |
| | | | | |
| | | | **S.D.** | **Rho** |
| Cross-section random | | | 0.5239 | 0.8666 |
| Idiosyncratic random | | | 0.2055 | 0.1334 |
| | | | | |
| R-squared | 0.5116 | | | |
| F-statistic | 74.6220 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.5722 | | | |
| | | | | |
| Num. of cross-sections | 29 | | | |
| Num. of periods | 10 | | | |
| N | 290 | | | |

From the result above, it can be seen that the difference with the fixed effects model is the error components also include idiosyncratic random. Idiosyncratic random represents the error component that is different across cross-sections and time. In the fixed effects, the error component is different across cross-sections, but constant over time. The Rho values of 0.86 and 0.13 for cross-section random and idiosyncratic random respectively mean how these components comprise 86% and 13% of the total variance. It could also be interpreted as the variance or randomness in the model is composed of 86% error component from cross sections—the ports in this case—and the rest 13% comes from idiosyncratic error or unobserved factor that changes over time and cross section.

### 4.2.2 Scenario 2: Port as Pairs

The second scenario is constructed by pairing all the 29 ports/26 countries and observe how the container throughput of a port will behave in response to the determinants. Each port is paired with one another resulting 812 port pairs for this scenario and multiplied by the 10 years' period ranging from 2009—2018. Meanwhile, the explanatory variables for this scenario is slightly more than the scenario 1. There are seven explanatory variables in total: one variables from maritime logistics aspects (LSBCI) and other six variables representing macroeconomics (ln GDP_I, ln GDP_J, ER_I, ER_J, TII, and FTA). This scenario will later on be explored by adding several interaction effects such as, port effects, cluster effects, and port-vs-port-partner effects to identify potential new partners or clusters. It is important to note that the scope of analysis in this research is bound onto the four major ports in Indonesia namely Tanjung Priok, Tanjung Perak, Belawan, and Makassar port. By using dummy variables indicating different clusters, it can be analyzed how each port cluster influences the container throughput in Indonesia's four major ports. The result from FEM with cross-section effects for the second scenario can be seen in the following table.

Table 4.14 Scenario 2: Fixed Effects Model (FEM) Result

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| Methods: Fixed effects (cross-sections) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | -4.1483 | 0.4052 | -10.2379 | 0.0000 |
| LSBCI | 2.7582 | 0.0815 | 33.8437 | 0.0000 |
| ln GDP_I | 0.2832 | 0.0135 | 20.9254 | 0.0000 |
| ln GDP_J | 0.3846 | 0.0135 | 28.4080 | 0.0000 |
| ER_I | -0.0568 | 0.0234 | -2.4295 | 0.0151 |
| ER_J | 0.0200 | 0.0234 | 0.8543 | 0.3929 |
| TII | 0.0138 | 0.0034 | 4.0770 | 0.0000 |
| FTA | 0.0572 | 0.0161 | 3.5564 | 0.0004 |
| | | | | |
| R-squared | 0.9729 | | | |
| F-statistic | 320.4110 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.4919 | | | |
| | | | | |
| Num. of cross-sections | 812 | | | |
| Num. of periods | 10 | | | |
| N | 8120 | | | |

The port effects from this estimation will be included in the attachment. From the table above, it can be seen that the variable of partner's exchange rate volatility (ER_J) are also insignificant in this scenario, proven from the probability (p-value) that exceeds 5% significance level or α. In this case, the ER_J variable shows 39% chance of the results could be random which exceed far from the point of rejection that has been set which is 5%. For the random effects model, the software running results the estimation as recapitulated in the following table.

Table 4.15 Scenario 2: Random Effects Model (REM) Result

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| Methods: Random effects (cross-sections) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | -1.7732 | 0.3691 | -4.8038 | 0.0000 |
| LSBCI | 2.6594 | 0.0770 | 34.5222 | 0.0000 |
| ln GDP_I | 0.3334 | 0.0113 | 29.5173 | 0.0000 |

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| ln GDP_JE | 0.2479 | 0.0113 | 21.9371 | 0.0000 |
| ER_I | -0.0589 | 0.0234 | -2.5179 | 0.0118 |
| ER_JE | 0.0193 | 0.0234 | 0.8273 | 0.4081 |
| TII | 0.0183 | 0.0032 | 5.6784 | 0.0000 |
| FTA | 0.0845 | 0.0155 | 5.4562 | 0.0000 |
| | | | | |
| | | | S.D. | Rho |
| Cross-section random | | | 0.9076 | 0.9479 |
| Idiosyncratic random | | | 0.2127 | 0.0521 |
| | | | | |
| R-squared | 0.3394 | | | |
| F-statistic | 595.5050 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.4132 | | | |
| | | | | |
| Num. of cross-sections | 812 | | | |
| Num. of periods | 10 | | | |
| N | 8120 | | | |

From the result above, it can be seen that the Rho values of 0.95 and 0.05 for cross-section random and idiosyncratic random respectively mean how these components comprise 95% and 5% of the total variance. It could also be interpreted as the variance or randomness in the model is composed of 95% error component from cross sections—the ports in this case—and the rest 5% comes from idiosyncratic error or unobserved factor that changes over time and cross section.

### 4.3 Model Selection

This subchapter contains the explanation of how the estimations with FEM and REM will be checked in terms of their suitability to be used. The test namely Hausman test is done to check whether the REM and FEM estimators differ substantially or not. It tests the cross-section random effects with Chi-Square value, $\chi^2$. The null and alternative hypothesis is as follow.

Hypothesis:

$H_0$: the REM and FEM estimators do not differ substantially (proceed with REM)

$H_A$: the REM and FEM estimators differ substantially (proceed with FEM)

If the null hypothesis is rejected, it can be concluded that the REM is not appropriate because the random effects are likely to be correlated with one or more explanatory variables. This diagnostic test will be conducted for both scenarios.

### 4.3.1 Scenario 1

The result of Hausman test for the first scenario is presented in the following tables. It covers the information of the verdict between the two models and a comparison between the coefficients of fixed effects and random effects.

Table 4.16 Scenario 1: Hausman Test

| ***Hausman Test*** | | | |
|---|---|---|---|
| **Chi-Sq. Statistic** | **df** | **Probability** | |
| 7.3330 | 4 | 0.1193 | |

| Cross-section random effects test comparisons: | | | |
|---|---|---|---|
| **Explanatory variables** | **Fixed** | **Random** | **Probability** |
| PLSCI | 0.0238 | 0.0259 | 0.1214 |
| MM | 0.0942 | 0.0462 | 0.0176 |
| ln GDP | 0.2725 | 0.2176 | 0.2162 |
| ER | -0.0496 | -0.0457 | 0.5054 |

From the table above, it is obvious that The Hausman test accepts the null hypothesis of REM and FEM estimators that do not differ substantially since the probability that is more than 0.05. As a result, the model can be proceeded with REM for scenario 1. From the bottom part, all variables are statistically insignificant except for multimodal facility (MM).

### 4.3.2 Scenario 2

The result of Hausman test for the second scenario is presented in the following tables. It covers the information of the verdict between the two models and a comparison between the coefficients of fixed effects and random effects.

Table 4.17 Scenario 2: Hausman Test

| ***Hausman Test*** | | | |
|---|---|---|---|
| **Chi-Sq. Statistic** | **df** | **Probability** | |
| 437.2135 | 7 | 0.0000 | |

| Cross-section random effects test comparisons: | | | |
|---|---|---|---|
| **Explanatory variables** | **Fixed** | **Random** | **Probability** |
| LSBCI | 2.7582 | 2.6594 | 0.0002 |
| ln GDP_I | 0.2832 | 0.3334 | 0.0000 |
| ln GDP_J | 0.3846 | 0.2479 | 0.0000 |
| ER_I | -0.0568 | -0.0589 | 0.0040 |
| ER_J | 0.0200 | 0.0193 | 0.3616 |
| TII | 13.7725 | 18.2610 | 0.0000 |
| FTA | 0.0572 | 0.0845 | 0.0000 |

From the table above, The Hausman test rejects the null hypothesis of REM and FEM estimators that do not differ substantially since the probability that is less than 5% significance level. As a result, REM can be rejected in favor of FEM for scenario 2. From the bottom part, all variables are statistically significant except for exchange rate volatility of port partner (ER_J). The different result between estimator that is chosen for each scenario can be caused by the presence of dummy variables that is more time-invariant in the first scenario. The relation is fixed effects model tend to remove the significance of time-invariant dummy variables which in this case is the MM variable. During the period under study, there is not much variation of multimodal facility in the port throughout the 10 years. Therefore, the scenario 1 is assigned better with random effects.

## 4.4 Assumption Testing

As classic linear regression model has, panel data regression also holds the assumption of BLUE (Best Linear Unbiased Estimator). There are several tests of assumptions that are done in this research.

### 4.4.1 Multicollinearity Test

Multicollinearity occurs when a perfect linear relationship exists among some or all explanatory variables in a regression model (Gujarati & Porter, 2008).

The existence of multicollinearity is undesirable since it results a biased model where the independent variables explain one another. This is strictly not allowed in a least square model. Common detection methods of multicollinearity are through observing the correlation matrix and variance-inflating factor (VIF). For the VIF, it can be obtained by calculating with the following formula.

$$VIF = \frac{1}{(1 - R^2)} \tag{4.3}$$

where:

VIF : variance-inflating factor

$R^2$ : R-squared value of the regression model among independent variables

The value of VIF itself implies on how inflated the variance of an estimator by the presence of perfect collinearity. A VIF score that exceeds 10 (R-squared more than 90%) is said to be highly collinear, so it is best to keep it under 10. However, the standard is still a debatable rule to date on how much score is considered as severe. This guidance is merely meant to be as a rule of thumb.

#### *4.4.1.1 Scenario 1*

In order to obtain the VIF score of scenario 1 model, the first thing to do is regressing each independent variable against one another. For example, to obtain the R-squared of PLSCI as the dependent variable, set the rest of the independent variables as the regressors. Then, save the R-squared value resulted from the estimation of each independent variable while being regressed on. The recapitulation of correlation matrix and VIF score of scenario 1 can be seen in the following table.

Table 4.18 Scenario 1: Correlation Matrix and VIF Score

| Correlation | ln CT | PLSCI | MM | ln GDP | ER | VIF | $R^2$ |
|---|---|---|---|---|---|---|---|
| **PLSCI** | 0.8761 | 1 | | | | 1.1616 | 0.1391 |
| **MM** | 0.2419 | 0.3352 | 1 | | | 1.1821 | 0.1541 |
| **ln GDP** | 0.5099 | 0.4009 | 0.4704 | 1 | | 0.0168 | -58.3791 |
| **ER** | -0.0535 | -0.0472 | -0.0309 | -0.0692 | 1 | 1.0005 | 0.0005 |

From the correlation test alone, it is obvious there is no perfect collinearity (correlation value equals to 1) between the explanatory variables. Likewise, the evaluation with VIF score also has shown no troublesome collinearity as all variables have VIF score less than 5. Hence, the scenario 1 is free of multicollinearity.

#### *4.4.1.2 Scenario 2*

Similar with the procedure conducted for scenario 1, each independent variable is regressed against one another. Then, using the saved R-squared value, the VIF can be calculated. The recapitulation of correlation matrix and VIF score of scenario 2 can be seen in the following table.

Table 4.19 Scenario 2: Correlation Matrix and VIF Score

| Correlation | ln CT | LSBCI | ln GDP_I | ln GDP_J | ER_I | ER_J | TII | FTA | VIF | R2 |
|---|---|---|---|---|---|---|---|---|---|---|
| LSBCI | 0.5184 | 1 | | | | | | | 1.1663 | 0.1426 |
| ln GDP_I | 0.5099 | 0.4300 | 1 | | | | | | 0.4966 | -1.0137 |
| ln GDP_J | -0.0056 | 0.4300 | -0.0277 | 1 | | | | | 0.4968 | -1.0127 |
| ER_I | -0.0535 | -0.0508 | -0.0692 | 0.0018 | 1 | | | | 1.0046 | 0.0046 |
| ER_J | -0.0004 | -0.0508 | 0.0018 | -0.0692 | -0.0117 | 1 | | | 1.0046 | 0.0046 |
| TII | 0.1344 | 0.1076 | -0.1714 | -0.1974 | -0.0113 | -0.0055 | 1 | | 1.0621 | 0.0585 |
| FTA | -0.0127 | 0.0881 | -0.0927 | -0.0927 | -0.0175 | -0.0175 | 0.2188 | 1 | 1.0494 | 0.0471 |

From the correlation matrix above, there is no perfect collinearity (correlation value equals to 1) between the explanatory variables of scenario 2. Likewise, the evaluation with VIF score also has shown no troublesome collinearity as all variables have VIF score less than 5. Hence, the scenario 2 also does not violate the assumption of no multicollinearity.

### 4.4.2 Autocorrelation Test

Autocorrelation is the condition occurred when residuals are dependent which means it affects the same individual in the next period. Thus, it is more common in time-series data. However, since panel data also consists of time-series, the diagnostic of autocorrelation in the data become apparently needed to ensure the model is still efficient. Although, the estimators have autocorrelation in it, the OLS estimators remain unbiased and consistent, yet it is no longer efficient. In this research the autocorrelation is detected through Wooldridge procedures in EViews software. First, regress the model as usual with OLS, but include *White period* for coefficient covariance method option. Then, save the residuals from the estimation. Sample any one period and generate one period lagged series from the residuals. After that, test autocorrelation in the first-differenced equation by regressing the residuals from this specification on the lagged residuals using data for the sample year. Under the null hypothesis of the original idiosyncratic errors are uncorrelated, the residuals from this equation should have an autocorrelation coefficient of -0.5 (Wooldridge, 2016). Compare the coefficient of the lagged residuals with the autocorrelation coefficient though formal test of Wald hypothesis test.

Hypothesis:

$H_0$: Residuals have no first-order autocorrelation

$H_A$: Residuals have first-order autocorrelation

Reject the null hypothesis if the probability of F-statistic is less than 5% significance level.

#### *4.4.2.1 Scenario 1*

The result for scenario 1 is summarized in the following table. The probability of the F-statistic is almost zero leaving the null hypothesis to be rejected. This indicates that the first scenario model has autocorrelation in its data. There are various possible sources that can trigger this problem. In this case, the number of cross-sections that is larger than the number of time-series is very likely to trigger autocorrelation. Moreover, the variables consist of economics variable that usually have trend in their data pattern.

Table 4.20 Scenario 1: Wooldridge Autocorrelation Test

| *Wooldridge autocorrelation test* | | | |
|---|---|---|---|
| | **Value** | **df** | **Probability** |
| F-statistic | 737.3927 | (1, 28) | 0.0000 |

#### *4.4.2.2 Scenario 2*

Likewise, the scenario 2 also shows an autocorrelation behavior in their residuals as the following table has presented. It is even more severe since the number of cross-sections has almost 40 times the scenario 1. With higher degree of freedom, the estimation model is limited to restrictions like this. In conclusion, both scenario 1 and 2 suffer from autocorrelation. Later on, there will be explained how to correct or accommodate the condition in order to maintain efficiency of the estimators.

Table 4.21 Scenario 2: Wooldridge Autocorrelation Test

| *Wooldridge autocorrelation test* | | | |
|---|---|---|---|
| | **Value** | **df** | **Probability** |
| F-statistic | 139668.5 | (1, 811) | 0.0000 |

### 4.4.3 Heteroscedasticity Test

Another assumption that should be checked in estimating with panel data is heteroscedasticity. Heteroscedasticity test is done to check whether irregular pattern of variation of the error term exists. The thing to note in the panel data case is that heteroscedasticity is common for cross-section series. Hence, in this research the heteroscedasticity might be found. Especially, the presence of dummy variables used in this research (multimodal facility and free trade agreements) that in nature are prone to heteroscedasticity (Frost, 2019) as it does not really exhibit time-variant characteristics during the period observed.

Hypothesis:

$H_0$: Residuals are homoscedastic

$H_A$: Residuals are not homoscedastic

With the null hypothesis as shown above, the heteroscedasticity test will reject the null hypothesis if the p-value is less than 5% significance level. The test will utilize panel cross-section heteroscedasticity likelihood ratio (LR) test.

*4.4.3.1 Scenario 1*

Scenario 1 which has 29 cross sections turns out to have heteroscedastic residuals. The summary of the test can be seen in the following table. The null hypothesis of homoscedasticity is rejected since the probability of the likelihood ratio which is less than 0.05 or 5% significance level. This situation violates the OLS assumption of homoscedastic residuals.

Table 4.22 Scenario 1: Heteroscedasticity Test

| ***Panel cross-section heteroscedasticity LR test*** | | | |
|---|---|---|---|
| | **Value (λ)** | **df** | **Probability** |
| Likelihood ratio | 305.5733 | 29 | 0.0000 |

*4.4.3.2 Scenario 2*

Scenario 2 which has more cross sections than scenario 1 should be carefully observed as it has higher chance of heteroscedasticity. It turns out true that the residuals have heteroscedasticity. The summary of the test can be seen in the following table. The null hypothesis of homoscedasticity is rejected since the probability of the likelihood ratio which is less than 0.05 or 5% significance level. In conclusion, both scenario 1 and 2 suffer from heteroscedasticity. To correct for the observed heteroscedasticity, a standard error should be introduced.

Table 4.23 Scenario 2: Heteroscedasticity Test

| ***Panel cross-section heteroscedasticity LR test*** | | | |
|---|---|---|---|
| | **Value (λ)** | **df** | **Probability** |
| Likelihood ratio | 6227.6070 | 812 | 0.0000 |

## 4.5 Generalized Least Squares (GLS) with Weighted Cross-Sections Estimation: Responding to Autocorrelation and Heteroscedasticity

According to the previous subchapter there are two out of three assumptions that are violated. In this case, there should be a mitigation for such situation to maintain the efficiency of the estimator result. The chosen procedure to follow-up from the violated assumptions of homoscedasticity and no autocorrelation here is by generating the estimation with Generalized Least Squares (GLS) and weight the cross-sections. Basically, random effects model (REM) itself is estimated with this approach as well. GLS can produce a BLUE (Best Linear Unbiased Estimation) estimator while accommodating data that has heteroscedasticity, autocorrelation, and/or cross-section dependence. It is also known as **estimated (or feasible) generalized least squares (EGLS).** Here, the original variables from OLS estimation are transformed disregarding the problems of heteroscedasticity and/or autocorrelation in order to satisfy the assumptions of the classical model of least squares. Then, the variables can be applied back into the OLS afterwards. In short, "GLS is OLS on the transformed variables that satisfy the standard least-squares assumptions" (Gujarati & Porter, 2008).

### 4.5.1 Scenario 1

The procedure of panel EGLS through EViews is pretty direct. The set ups considered are choosing *GLS Weights* and choose the *Cross-section weights* while for the *Coefficient covariance method*, choose *Cross-section weights (PCSE)* and check the *No d.f. correction*. The summary of the result from EGLS can be seen in the following table.

Table 4.24 Scenario 1: Panel EGLS Method Summary

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| Methods: Panel EGLS (Cross-section weights) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| C | 9.2071 | 0.4414 | 20.8607 | 0.0000 |
| PLSCI | 0.0298 | 0.0005 | 64.0662 | 0.0000 |
| MM | -0.3573 | 0.0511 | -6.9911 | 0.0000 |
| ln GDP | 0.1750 | 0.0165 | 10.5960 | 0.0000 |
| ER | -0.1231 | 0.3666 | -0.3357 | 0.7373 |
| | | | | |
| R-squared | 0.9344 | | | |
| F-statistic | 1015.3680 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.2911 | | | |
| | | | | |
| Num. of cross-sections | 29 | | | |
| Num. of periods | 10 | | | |
| N | 290 | | | |

In order to alleviate the interpretation, the result from EGLS above is compared with the result from FEM and REM. The comparison of those three is presented in the following table.

Table 4.25 Scenario 1: Comparison of FEM, REM, and Weighted Cross-Section EGLS

| **Explanatory variables** | **Coefficients** | | |
|---|---|---|---|
| | **FEM** | **REM** | **EGLS** |
| | | | cross-section weights |
| Dependent variable: Container throughput (ln CT) | | | |
| | | | |
| C | 6.539 *** | 7.959 *** | 9.207 *** |
| PLSCI | 0.024 *** | 0.026 *** | 0.03 *** |
| MM | 0.094 | 0.046 | -0.357 *** |
| ln GDP | 0.273 *** | 0.218 *** | 0.175 *** |
| ER | -0.05 | -0.046 | -0.123 |
| | | | |
| R-squared | 0.9751 | 0.5116 | 0.9344 |
| Prob. (F-statistic) | 0.0000 | 0.0000 | 0.0000 |

* the corresponding variable is significant at 10% significance level; ** significance at 5% level; *** significance at 1% level

From the table above, it can be observed how EGLS method compromise the estimation from FEM and REM while fitting the heteroscedasticity and autocorrelation. EGLS has increased the R-squared from the previously chosen method (REM) by 82%. If the result from Hausman test—which is choosing the REM estimation—is directly accepted without checking the assumptions and trying to improve it, the scenario 1 will not get the 93.44% R-squared model from EGLS. Aside the R-squared value difference, the significance of variables between these three also slightly differs which can be seen from the probability or p-value of each variable. The MM variable in EGLS estimation is now significant at 1%, but with negative coefficient. While in FEM and REM, the MM variable is insignificant with positive coefficient. The MM sign from EGLS contradicts with the sign in correlation test in which the multimodal facility has positive correlation towards container throughputs.

### 4.5.2 Scenario 2

Similar procedure with what has been done for scenario 1 is repeated for obtaining the result of scenario 2. The panel EGLS estimation of scenario 2 is summarized in the following table.

Table 4.26 Scenario 2: Panel EGLS Method Summary

| **Explanatory variables** | **Coefficients** | **Std. Error** | **t-Statistic** | **Probability** |
|---|---|---|---|---|
| Methods: Panel EGLS (Cross-section weights) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | 10.4802 | 0.1492 | 70.2660 | 0.0000 |
| LSBCI | 3.4355 | 0.0343 | 100.1575 | 0.0000 |
| ln GDP_I | 0.2565 | 0.0034 | 74.8087 | 0.0000 |
| ln GDP_J | -0.1369 | 0.0038 | -35.8127 | 0.0000 |
| ER_I | -0.0608 | 0.0582 | -1.0445 | 0.2963 |
| ER_J | 0.0519 | 0.0372 | 1.3927 | 0.1637 |
| TII | 0.0453 | 0.0013 | 34.7348 | 0.0000 |
| FTA | -0.1166 | 0.0095 | -12.3025 | 0.0000 |
| | | | | |
| R-squared | 0.7700 | | | |
| F-statistic | 3880.2350 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.0977 | | | |
| | | | | |
| Num. of cross-sections | 812 | | | |
| Num. of periods | 10 | | | |
| N | 8120 | | | |

In order to ease the interpretation between models that have been tried, the result from EGLS above is compared with the result from FEM and REM. The comparison of those three is presented in the following table.

Table 4.27 Scenario 2: Comparison of FEM, REM, and Weighted Cross-Section EGLS

| Explanatory variables | Coefficients | | |
|---|---|---|---|
| | FEM | REM | EGLS |
| | | | cross-section weights |
| Dependent variable: Container throughput (ln CT) | | | |
| | | | |
| C | -4.148 *** | -1.773 *** | 10.48 *** |
| LSBCI | 2.758 *** | 2.659 *** | 3.436 *** |
| ln GDP_I | 0.283 *** | 0.333 *** | 0.256 *** |
| ln GDP_J | 0.385 *** | 0.248 *** | -0.137 *** |
| ER_I | -0.057 ** | -0.059 ** | -0.061 |
| ER_J | 0.02 | 0.019 | 0.052 |
| TII | 0.014 *** | 0.018 *** | 0.045 *** |
| FTA | 0.057 *** | 0.084 *** | -0.117 *** |
| | | | |
| R-squared | 0.9729 | 0.3394 | 0.7700 |
| Prob. (F-statistic) | 0.0000 | 0.0000 | 0.0000 |
| | | | |
| * the corresponding variable is significant at 10% significance level; ** significance at 5% level; *** significance at 1% level | | | |

From the table above, it can be observed how EGLS method also compromise the estimation of scenario 2 from FEM and REM while fitting the heteroscedasticity and autocorrelation. The difference with the result from scenario 1 is that instead of increasing the R-squared, the EGLS in scenario 2 decreases the R-squared value from the previously chosen method (FEM) by 26%. However, if the coefficients and their significance are evaluated, the values are making more sense with EGLS estimation rather than the FEM or REM. Take example of the common intercept value that in EGLS in now positive. Previously in REM and FEM, the values are negative which is kind of impossible for a container throughput to have negative volume. Another differences that can be spotted are the change of significance for ER_I variable (from 5% significance to insignificant) and the change of sign for FTA variable (from positive to negative). Nonetheless, the FTA sign is actually following the result from correlation matrix which shows negative correlation with container throughputs. In reality, the presence of FTA should affect positively towards the container throughput.

## 4.6 Model Testing

After the development of EGLS estimation, the goodness-of-fit of the model should be assessed. There are three common tests used which are partial significance test (t-test), simultaneous significance test (F-test), and coefficient determination test ($R^2$ test).

### 4.6.1 Partial Significance Test (t-test)

The partial significance test checks on how each explanatory variable significantly affecting the dependent variable. It is done by comparing the p-value of t-statistic that each explanatory variable has with the significance level of 5%.

Hypothesis:

$H_0$: the explanatory variable is partially insignificant towards the dependent variable

$H_A$: the explanatory variable is partially significant towards the dependent variable

If the probability of t-statistic < significance level (0.05), the null hypothesis is rejected. Meaning that the related explanatory variable is significantly able to affect the dependent variable.

#### *4.6.1.1 Scenario 1*

The summary of the t-statistic values of scenario 1 can be seen in the following table. From the four explanatory variables that scenario 1 have, all of them are significant except for the exchange rate volatility (ER). It exceeds the p-value of 0.05 even almost reaches 0.8. The p-value is the evidence to against a null hypothesis, the smaller the value, the stronger evidence to reject the null hypothesis. With significance level of 5% or 0.05, it means that there is only a room of 5% chance for the result to be random or happened by chance. In this case, the ER variable shows 73.7% chance of the result could be random which exceed far from the point of rejection that has been set which is 5%. Hence, statistically, the exchange rate volatility cannot explain the container throughput while the other variables such as, PLSCI index, the presence of multimodal facility (MM), and GDP are able to statistically affect the container throughput.

Table 4.28 Scenario 1: t-Statistic Summary

| Explanatory variables | t-Statistic | Probability |
|---|---|---|
| Methods: Panel EGLS (Cross-section weights) | | |
| | | |
| C | 20.8607 | 0.0000 |
| PLSCI | 64.0662 | 0.0000 |
| MM | -6.9911 | 0.0000 |
| ln GDP | 10.5960 | 0.0000 |
| ER | -0.3357 | 0.7373 |

*4.6.1.2 Scenario 2*

The summary of the t-statistic values of scenario 2 can be seen in the following table. From the seven explanatory variables that scenario 2 have, all of them are significant except for the exchange rate volatility (ER), be it the respected country's exchange rate volatility or the country partner's. This is similar with what has been found in scenario 1. The p-values of ER_I and ER_J exceed 0.05. In this case, the ER_I and ER_J variables show 29.6% and 16.4% chance of the results could be random which exceed far from the point of rejection that has been set which is 5%. Therefore, statistically, the exchange rate volatility cannot explain the container throughput while the other variables such as, LSBCI index, GDP of the country (GDP_I) and its partner (GDP_J), level of bilateral trade intensity (TII), and the presence of free-trade agreements in the country pairs (FTA) are able to statistically affect the container throughput.

Table 4.29 Scenario 2: t-Statistic Summary

| Explanatory variables | t-Statistic | Probability |
|---|---|---|
| Methods: Panel EGLS (Cross-section weights) | | |
| | | |
| C | 70.2660 | 0.0000 |
| LSBCI | 100.1575 | 0.0000 |
| ln GDP_I | 74.8087 | 0.0000 |
| ln GDP_J | -35.8127 | 0.0000 |
| ER_I | -1.0445 | 0.2963 |

| Explanatory variables | t-Statistic | Probability |
| --- | --- | --- |
| Methods: Panel EGLS (Cross-section weights) | | |
| ER_J | 1.3927 | 0.1637 |
| TII | 34.7348 | 0.0000 |
| FTA | -12.3025 | 0.0000 |

### 4.6.2 Simultaneous Significance Test (F-test)

The simultaneous significance test or F-test examines all the explanatory variables in terms of how they affect the dependent variable simultaneously.

Hypothesis:

$H_0$: all explanatory variables are not simultaneously significant towards the dependent variable

$H_A$: all explanatory variables are simultaneously significant towards the dependent variable

If the probability of F-statistic < significance level of 0.05, the null hypothesis is rejected which means all explanatory variable are simultaneously significant to affect the dependent variable.

#### *4.6.2.1 Scenario 1*

The summary of the F-statistic value of scenario 1 can be seen in the following table. From the p-value, it can be seen that it is less than the significance level of 0.05. Thus, simultaneously, PLSCI index, multimodal facility (MM), GDP of the country, and exchange rate volatility of the country's currency towards USD (ER) presented in the model are able to affect the container throughput.

Table 4.30 Scenario 1: F-Statistic Summary

| Methods: Panel EGLS (Cross-section weights) | |
| --- | --- |
| **F-Statistic** | **Probability** |
| 1015.3680 | 0.0000 |

#### *4.6.2.2 Scenario 2*

The summary of the F-statistic value of scenario 2 can be seen in the following table. Similar with the scenario 1, the p-value of EGLS estimation of scenario 2 is less than the significance level of 5% or 0.05. Thus, simultaneously, LSBCI index, GDP of the country (GDP_I) and its partner (GDP_J), exchange rate volatility of the country's currency (ER_I) and its partner (ER_J), level of bilateral trade intensity (TII), and the presence of free-trade agreements in the country pairs (FTA) presented in the scenario 2 are able to affect the container throughput.

Table 4.31 Scenario 2: F-Statistic Summary

| Methods: Panel EGLS (Cross-section weights) | |
|---|---|
| **F-Statistic** | **Probability** |
| 3880.2350 | 0.0000 |

### 4.6.3 Coefficient Determination ($R^2$) Test

Evaluating the value of $R^2$ is prominent to test how good the model explains the problem. Coefficient determination has value ranging between 0 and 1. The greater the value of $R^2$ (closer to 1) implies that the explanatory variables are able to explain all the information required in response to the changes in dependent variable.

#### *4.6.3.1 Scenario 1*

Scenario 1 with EGLS estimation method has shown an R-squared value of 93.44%. This can be interpreted that the four explanatory variables of PLSCI index, multimodal facility (MM), GDP of the country, and exchange rate volatility of the country's currency towards USD (ER) have the ability to explain the container throughput by 93.44%. In other words, as much as 93.44% of port container throughput can be explained by the model, while the remaining 6.56% of port container throughput is explained by other factors that are not included in the model. The values of R-squared and adjusted R-squared in this scenario are very much similar with only a 0.0009 adjustment.

Table 4.32 Scenario 1: R-squared Value Summary

| Methods: Panel EGLS (Cross-section weights) | |
|---|---|
| **R-squared** | **Adj. R-squared** |
| 0.9344 | 0.9335 |

#### *4.6.3.2 Scenario 2*

Scenario 2 with EGLS estimation method has shown an R-squared value of 77%. This implies that the seven explanatory variables of LSBCI index, GDP of the country (GDP_I) and its partner (GDP_J), exchange rate volatility of the country's currency (ER_I) and its partner (ER_J), level of bilateral trade intensity (TII), and the presence of free-trade agreements in the country pairs (FTA) have the ability to explain the container throughput by 77%. In other words, as much as 77% of port container throughput can be explained by the model, while the remaining 23% of port container throughput is explained by other factors that are not included in the model. The values of R-squared and adjusted R-squared in this scenario are very much similar with only a 0.0002 adjustment.

Table 4.33 Scenario 2: R-squared Value Summary

| Methods: Panel EGLS (Cross-section weights) | |
|---|---|
| **R-squared** | **Adj. R-squared** |
| 0.7700 | 0.7698 |

# CHAPTER 5
# ANALYSIS AND INTERPRETATION

This chapter covers the interpretation and analysis from the technical aspects on panel regression model(s) that have been obtained, the hypotheses checking and analysis, and various explorations of interaction effects from the base model. The exploration includes analysis on identifying potential port or country partners for each major ports in Indonesia.

## 5.1 Technical Analysis on Panel Regression Estimation

This subchapter contains the discussion regarding technical issues found in the development of panel regression estimations covering this research's topic. The discussion covers for both scenarios; how they are alike and what differs.

Firstly, the construction of each scenario is similar and different in some parts, obviously seen in the independent variables and the data manipulation. Yet, both also has shared the same independent variables such as, gross domestic product (GDP) and exchange rate volatility (ER). If scenario 1 is compared with scenario 2, this scenario is way simpler and direct. Since it uses port samples as the cross-sections (ports are treated as individuals) and treats the variables with minimum data manipulation. Meanwhile, scenario 2 pairs the port with each other to increase the number of observations while also catching insights of any different behavior that might arise when there is this pairing effect.

However, due to some limitations on the data that can be gathered, the information on container throughput specified up to the port-to-port level is not available. Hence, the value of container throughput as a dependent variable in scenario 2 is situated on the origin port for each pair related to that port. So, the same value in the same period is repeated across the cross-sections (port pairs). Such transformation is uncommon, but the logic is similar to the case of regression with a dummy variable as the regressand (dependent variable). This could result a drawback in terms of the precision of the independent variable's coefficients.

Another form of data manipulation applied for scenario 2 is the logarithmic transformation of the dependent variable of container throughput (CT) and the independent variable of gross domestic product from origin country (GDP_I) as well as from partner country (GDP_J). This transformation also can be found in scenario 1, but without the GDP_J since scenario 1 does not treat the data in pairs. The natural logarithm form is popular for transforming economic variables such as a GDP, GNP, population, money supply, employment, productivity, and trade deficit (Gujarati & Porter, 2008). This transformation into natural logarithm variables resulting a semi-log or log-lin regression which is the combination of logarithm and linear variables in one regression equation. Because the rest of the independent variables are in their original linear form. The functions of having natural logarithm variables are twofold: to ease the interpretation of the coefficient and to reduce skewness and heteroscedasticity that might present in economic variables (Gujarati & Porter, 2008).

The data that has been arranged is processed afterwards. As been described in the previous chapter, the model in both scenarios turned out to violate the classical assumptions of least squares regression which are the homoscedasticity and no autocorrelation. For the first assumption, homoscedasticity, the term itself means that the residuals have equal variance. In other words, the residuals are not allowed to have irregular pattern of variation i.e. the ability to correlate or predict any of the explanatory variables. The possible cause in this case is the presence of outliers in the samples. As been presented earlier, the samples collected are from various ports/countries and take example of their container throughputs that also vary. From Sihanoukville Port in Cambodia that handles, on average, the smallest container throughput per year (310,952 TEUs) to Singapore Port that handles 100 times larger volume (31,284,500 TEUs). However, removing outliers in regression analysis has always been debatable and it highly depends on the purpose of the research. Moreover, dummy variables that are used in this research have weak time-variant traits especially the multimodal facility variable (MM). It is known that dummy variables are prone to heteroscedasticity (Frost, 2019).

Another assumption that got violated by both scenarios is no autocorrelation. Autocorrelation represents the presence of explanatory power that the independent variables do not describe. The residuals from the model should not be dependent across periods. Hence, time-series data is more susceptible to this condition. The possible cause for autocorrelation in this research comes from the macroeconomic variable, GDP. Because in general, most of economic time series exhibit positive autocorrelation. Either moving upward or downward over an extended period of time. In general, autocorrelation can be resolved by adding an independent variable that is tied to a more pertinent time.

Both heteroscedasticity and autocorrelation imply similar consequences on the ordinary least squares (OLS) estimation. The presence of any of them induces an OLS estimation that is no longer the best and most efficient. Coefficient estimates are still unbiased, but it makes them less precise and unstable (Gujarati & Porter, 2008; Kaufman, 2013). The standard errors might be misleading since less precision leads to the coefficient estimates that swaying further from the actual/population value, hence the unreliable standard errors. OLS cannot detect this increase of variance which consequently calculates t-statistic and F-statistic with an underestimated variance. Then, this problem produces smaller p-value leading to a statistically significant variable while it actually is not.

In response to those possible risks from assumption violation, generalized least squares (GLS) is considered the most suitable to hedge the risk of producing OLS results that cannot be trusted. Specifically, the estimated GLS (EGLS) can accommodate all the problems above by weighting the sum of residual squares. In more practical means, the coefficient of each variable is weighted with the inverse of its variance from the fitted value. This means observation with larger variance will be accounted less or put simply the EGLS emphasizes observations with less variability. The results presented in Subchapter 4.5 have shown a clear proof of these explanations. Take a look at the Table 4.27 of the comparison between the three methods: fixed effects model (FEM), random effects model (REM), and EGLS with cross-section weights. The R-squared of FEM shows a very promising value of 97.3% compared with the REM and EGLS. However, since the heteroscedasticity and autocorrelation are known, the effect of masked variation can be seen in how exchange rate volatility in the country origin (ER_I) is significant at 5% in both FEM and REM, yet it turns insignificant in EGLS. The variance of ER_I is underestimated under OLS estimation, hence the misleading p-value. However, for the sake of precision, the R-squared value of EGLS is 26% lower than FEM, yet twice the REM. Under EGLS, the model can explain container throughput by 77%. Then, what if the insignificant variables are taken out from the model? The value of R-squared remains the same along with the coefficient and significance of the remaining variables. To rationalize this, one needs to go back to the essence of R-squared where it is expected that the result based on the sample chosen will be as close to the population as possible (aiming high R-squared value). There are certain conditions that are very likely to have high R-squared values (i.e. 90s percent) and considered valid. If the object under study has very precise and accurate measurements, then it is possible. In contrast, behavior-related variables (e.g. human, social, psychology) involves much more unexplainable variability hence the lower R-squared values, commonly less than 50% (Frost, 2019). The variables such as connectivity indices, GDP, exchange rate volatility, and bilateral trade intensity index (TII), are using up to 7 decimals precision. The presence of trend pattern in the data (i.e. GDP) also produces high R-squared values because it is simply in line with the nature of linear regression. Therefore, the EGLS estimation is preferable as the proposed fixed effects model (FEM) and random effects model (REM) have results that are not as efficient as what EGLS has.

Another approach in analysis that can be done to enrich the insight is by dividing the data points into two: half period for modelling and the other half for analysis and results matching. In this research, if not all the 10-year data is included and the data considered for modelling is only the first five years (2009 – 2013) then the result is as shown in the following table. In terms of R-squared value, the 5-year period data for scenario 1 results an increase of 1% only. The coefficient magnitude between these two models also does not really differ and the significance of each variable remains the same. Therefore, there is not much of different in terms of interpretation.

Table 5.1 Scenario 1: Comparison between model with 10-year period vs 5-year period

| **Explanatory variables** | **10-year period** | | **5-year period** | |
|---|---|---|---|---|
| | **Coefficients** | **Probability** | **Coefficients** | **Probability** |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | 9.2071 | 0.0000 | 8.1191 | 0.0000 |

| Explanatory variables | 10-year period | | 5-year period | |
|---|---|---|---|---|
| | Coefficients | Probability | Coefficients | Probability |
| PLSCI | 0.0298 | 0.0000 | 0.0309 | 0.0000 |
| MM | -0.3573 | 0.0000 | -0.4654 | 0.0000 |
| ln GDP | 0.1750 | 0.0000 | 0.2162 | 0.0000 |
| ER | -0.1231 | 0.7373 | -0.5697 | 0.3633 |
| | | | | |
| R-squared | 0.9344 | | 0.9432 | |
| Num. of cross-sections | 29 | | 29 | |
| Num. of periods | 10 | | 5 | |
| N | 290 | | 145 | |

However, if the result is wanted to be used for forecasting the container throughput, the model does not perform really well as the data points are small resulting inconsistent result across ports or cross-sections. The comparison between the actual and forecast value from the other half of the period (2014 – 2018) can be seen in the following figure. In different ports, it could overestimate the actual container throughput (e.g. Algericas Port, Hamburg Port, and Havre Port) or underestimate the actual ones (e.g. Shanghai Port, Singapore Port, and Hongkong Port). Therefore, it is best to keep in mind that the result in this research requires further analysis and development before being utilized as a forecasting method of container throughput.

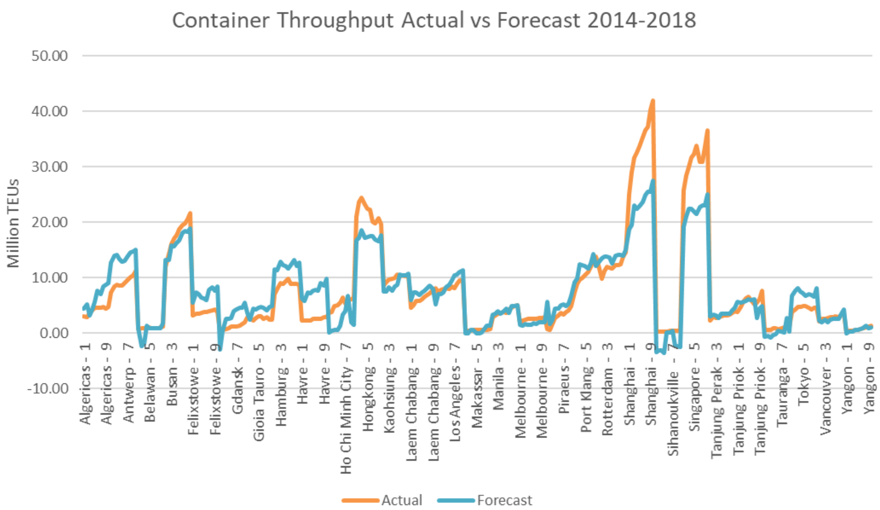


Figure 5.1 Container throughput actual vs forecast with the 5-year data model (2014 – 2018)

## 5.2 Hypothesis Analysis: Maritime Logistics Factor

This subchapter consists of discussion and analysis of the hypotheses from maritime logistics factor: Port Liner Shipping Connectivity Index (PLSCI), Liner Shipping Bilateral Connectivity Index (LSBCI), and the presence of multimodal facility (MM).

The hypothesis regarding connectivity indices such as, PLSCI and LSBCI on container throughput is that it has a positive effect on container throughput. Likewise, multimodal facility also hypothesized to have positive impact on container throughput. The result from the EGLS estimation shows for every 1-unit increase of PLSCI score, the container throughput increases by 3% while holding everything else constant (refer to Table 4.24). In scenario 2, every 0.01-unit increase of LSBCI, container throughput increases by 3.4% (refer to Table 4.26). For LSBCI, it has a different measurement with PLSCI in terms of the normalization of the value. PLSCI takes the value from 0 to infinity while LSBCI (non-normalized) takes the value from 0 to 1, hence the coefficient that seems larger. In essence, it has no difference.

These relationships are in line with the theory and the hypothesis in this research. Better connectivity should increase the volume of container handled by a port. These connectivity indices are a proxy for the accessibility to global trade. PLSCI score represents the higher the level, the easier it is for a country or a port to access the global maritime freight transport system. While LSBCI score reflects a country pair's integration level in the global liner shipping network. The indices are also a form of measure of competitiveness and trade facilitation (UNCTAD, 2019).

It is proven by how the ports that have the highest PLSCI values are whose countries that actively involved in trade. It is no contest how export-oriented economies such as China with its Shanghai Port can top the rank and same goes for Hongkong Port. The transshipment hub, Singapore Port, also ranked second among the samples in this research. From the top 10 PLSCI alone, it can be seen how Asian ports dominate the rank with some European ports following it. For Indonesian ports, none of them presents until top 20 in which Tanjung Priok Port placed 17$^{th}$

in the list from the 29 port samples. Among the Indonesian port, currently Tanjung Priok is indeed the largest and best port available, followed by Tanjung Perak, Belawan, then Makassar. In the global context, Tanjung Priok Port gets as closest as to top 70 worldwide based on its connectivity (PLSCI score).

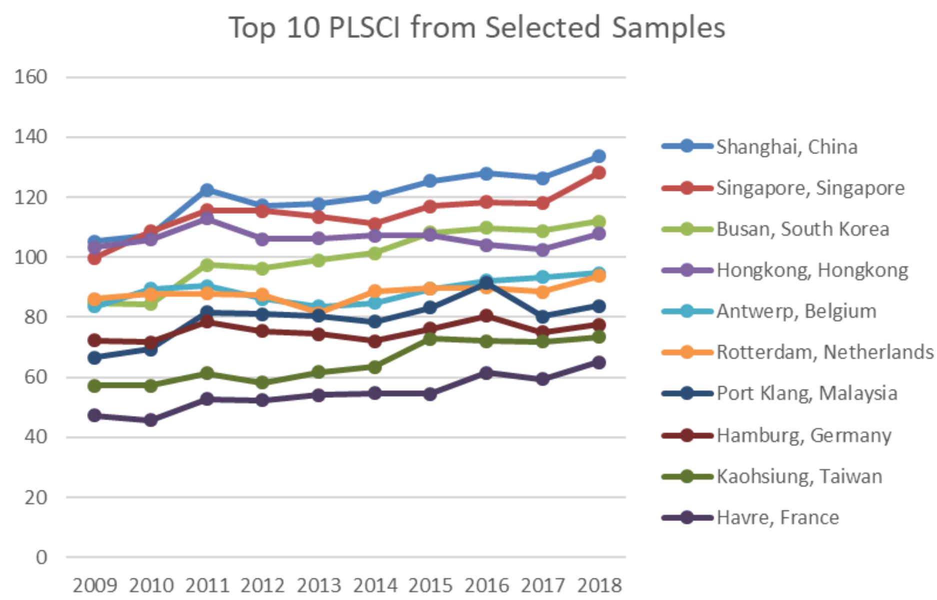


Figure 5.2 Top 10 PLSCI from Selected Samples

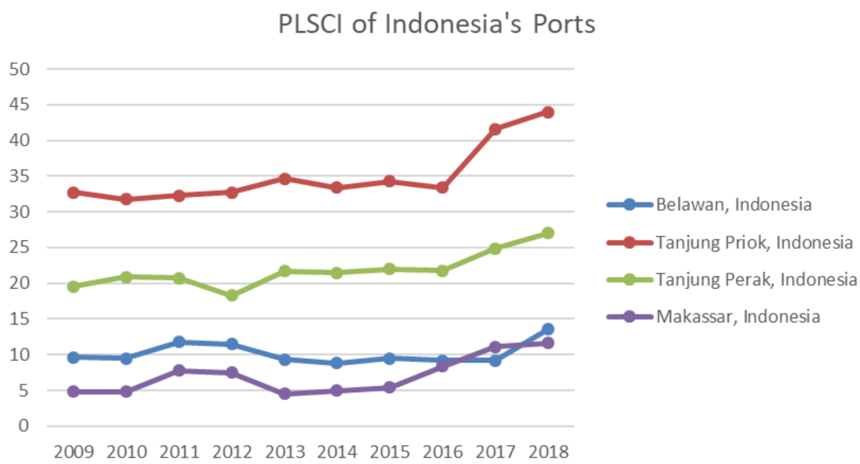


Figure 5.3 PLSCI Score of Indonesian Ports

Looking deeper to the breakdown of PLSCI, one of its components is number of ports/countries connected through direct connections. Establishing direct connection with every country/port is technically and economically impossible as the volume may not be enough or the distance between ports that is way too far. Container shipping networks are rather established as sequences of port calls along a route that commonly referred with “pendulum network” (Rodrigue, 2010). Thus, a set of connections between country pairs along the route is required to enhance maritime trade and eventually the container throughput itself. Currently, the link between countries are dominated by transshipment with 62% of all country pairs require at least one transshipment and 18.6% require two transshipments. Only a share of 17% of all country pairs that are directly connected (Rodrigue, 2010). Therefore, this is the linkage that aligns PLSCI and LSBCI. If PLSCI has number of ports connected through direct connection as its building block, LSBCI also has that and they add number of transshipments required between country pairs as its components. Therefore, how one port or country builds their connectivity with their partners are important to increase container throughput. Another finding about LSBCI is that the top connected pairs are always the intra-cluster trade ones e.g. in 2018 the best pair is South Korea and China (intra-Asia) followed by UK and Netherlands (intra-Europe). The rest of the top 10 also follows the same intra-cluster pattern. Only after the top 20, an Asia-Europe pair can be found in the list, yet the Asia country mentioned is still dominated by China (e.g. China-Belgium, China-UK, China-Spain). Similar finding also appears in Indonesian ports context. The top 10 for Indonesia country also is also dominated by intra-Asia partner, but now USA and Canada comes in $6^{th}$ and $9^{th}$ place respectively as a part of Northern America cluster. There is only Belgium as a partner from European country included in the rank list.

Table 5.2 Top LSBCI Worldwide (left), Indonesia (right)

| Rank | Pair_ij | 2018 | Rank | Pair_ij | 2018 |
|---|---|---|---|---|---|
| 1 | South Korea_China | 0.8442 | 1 | Indonesia_Singapore | 0.5043 |
| 2 | UK_Netherlands | 0.8197 | 2 | Indonesia_Malaysia | 0.4786 |
| 3 | Belgium_UK | 0.8185 | 3 | Indonesia_Hongkong | 0.4455 |
| 4 | Malaysia_Singapore | 0.8091 | 4 | Indonesia_China | 0.4424 |
| 5 | China_Singapore | 0.7960 | 5 | Indonesia_Thailand | 0.4360 |
| 6 | Belgium_Germany | 0.7822 | 6 | Indonesia_USA | 0.4348 |
| 7 | Belgium_Netherlands | 0.7812 | 7 | Indonesia_Vietnam | 0.4219 |

| Rank | Pair_ij | 2018 | Rank | Pair_ij | 2018 |
|---|---|---|---|---|---|
| 8 | UK_Germany | 0.7784 | 8 | Indonesia_South Korea | 0.4042 |
| 9 | Hongkong_China | 0.7744 | 9 | Indonesia_Canada | 0.4028 |
| 10 | Germany_Netherlands | 0.7743 | 10 | Indonesia_Belgium | 0.3992 |
| | | | | | |
| -3 | Poland_Myanmar | 0.2071 | -3 | Indonesia_Poland | 0.3169 |
| -2 | Poland_Cambodia | 0.2009 | -2 | Indonesia_Myanmar | 0.2626 |
| -1 | Cambodia_Myanmar | 0.1915 | -1 | Indonesia_Cambodia | 0.2169 |

Besides from the indices, another important aspect of maritime logistics that has not been covered by any of the indices is the presence of multimodal infrastructure in a port (MM). When a port can provide such facility, it could attract more container traffic to the port because the hassle to continue the distribution with different transportation modes is covered by the available interconnection directly from the port itself. In this research, this variable has surprising results of negative effect on container throughput while it actually should affect positively. Although, the correlation between multimodal facility and container throughput already indicates positive correlation despite its weak strength (0.2419). In average, the container throughput of ports that have multimodal facilities is lower by 35.73%. from ports that do not have the facility yet. The negative sign in this finding is most likely caused by how most of the ports in the sample already have such facility before the period of observation (2009—2018). There are 19 out of the 29 ports that already have multimodal facility. The rest just got in the middle of observation period or do not have at all until the end of observation period. The strange behavior of Belawan (refer to Figure 5.4) that opened their railway facility in 2010, but closed it two years later might also disrupt the overall result of this variable.

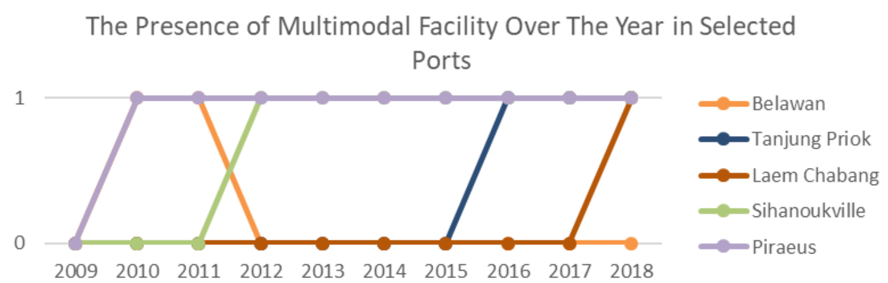


Figure 5.4 The Presence of Multimodal Facility Over The Year in Selected Ports

In reality, the presence of multimodal facility is very useful especially for countries with a large land area e.g. North America, Europe, China. It is because from the container at ports, the need to be distributed over the land becomes extensive as the coverage areas get larger. Countries in Europe for example even got extra leverage to expand the cross-border trade through land transport since the neighboring countries are in the same continent and connected via railway. Hence another reason why intra-Europe scores of LSBCI prevail the other pairs.

## 5.3 Hypothesis Analysis: Macroeconomics Factor

This subchapter consists of discussion and analysis of the hypotheses from macroeconomics factor: gross domestic product (GDP), bilateral trade intensity index (TII), exchange rate volatility (ER), and the presence of free-trade agreements (FTA).

As much as port performances and infrastructures are important to achieve growth expectation, the port's hinterland induces growth potential by anchoring traffic and inbound/outbound of container flows (Rodrigue, 2010). Therefore, the GDP growth of a country where the port located is said to be prominent in growing the volume of container handled. In this study, when the port is treated as individual without being paired, the average increase of container throughput for every 1% increase of GDP is 17.50%. On the other hand, in the case of scenario 2 when the port is being paired, the average increase of port origin container throughput due to 1% increase of the country origin's GDP is 25.65% and their partner's GDP influences negatively instead with the decrease of container throughput by 13.69%. This could happen because when the country partner has an increase in their GDP, their container throughput increases as well, yet the destination or origin of their additional containers do not necessarily mean from the respected partner alone. Moreover, the trade competition that exists among the countries could also be the reason behind this finding. Nonetheless, the positive relationship between containerized cargo and GDP has been extensively studied and approved by academics (Liu & Park, 2011; Ducruet, 2009) and United Nations organization (UNCTAD, 2011; UNESCAP, 2011).

Moreover, GDP in this research is proven as a significant factor with the largest magnitude of coefficient hence implying it as the most critical variable that influences port container throughput in this model. Meaning that the GDP can affect the container throughput more greatly compared with other variables. For instance, if the impact of GDP is compared with PLSCI, the GDP is more critical in predicting the container throughput as its coefficient is larger than PLSCI. A percent increase of GDP can increase the container throughput by 17.50% while PLSCI only around 1%[1]. However, GDP alone could be a vague determinant in the case of shorter time-horizon (short to medium-term) i.e. quarterly or monthly seasonality of throughput (Hackett, 2012).

Besides GDP, exchange rate volatility (ER) is also considered in this study. Theoretically, the higher variability of exchange rate leads to less trade volume realized (Ethier, 1973). However, there are some mixed results on how this variable behave in different studies. Previous study by Tenreyro (2006) indicates a negative relationship of exchange rate variability on trade if least squares estimation is used. Some previous studies also used simply the nominal exchange rate instead of the exchange rate volatility (Kim, 2016; Haris, 2019). According to Table 4.24 and Table 4.26, the results of estimation method from both scenarios point to the absence of any statistically significant causal effect from exchange rate variability to port container throughput. However, the lack of this significant effect can be rationalized by the fact that positive effects could also possibly occurred due to exchange rate fluctuations. For instance, when there is a currency fluctuation which leads to fluctuating prices, this may result an average higher profit for certain companies compared with stable price. Hence the larger volume of trade in general (Broda & Romalis, 2010; Bacchetta & van Wincoop, 2001) which eventually increases the volume of the cross-border trade being containerized for shipping. The next possible reason of the insignificance is the availability of wide financial instruments options (e.g. forward contract and currency options) to confine

[1] Referring to PLSCI coefficient (0.0298) in Table 4.24. Since the dependent variable is in natural logarithm while PLSCI is in linear form, the coefficient value cannot be interpreted directly if the approach wants to follow the same concept of elasticity that natural logarithm form gives which is in percentage. Therefore, anti-log is used to obtain the change in percent. With anti-log of 0.0298 is 1.0286, it means that for every 1% increase of PLSCI score, the container throughput increases by 1.03% while holding everything else constant.

exchange rate risks (Ethier, 1973). In this research, US Dollar is set as the benchmark of each currency to convert to since it is more universal and extensively used all over the world especially in maritime trade. The reason to prefer USD over the currency of the country's partner as comparison is referring to the real practice of trade transaction that tends to be done with more universal currencies e.g. USD or Euro. However, for the sake of simplification and reduce the complexity of this research, the exchange rate volatility calculation is tied to USD for all country pairs. This means that the currency option is assumed to be limited to USD whereas the possibility of transactions using other currency of choice exists. For example, a company in Indonesia can decide to proceed the transaction with its partner in Malaysia using Euro instead of US Dollar since the conversion rate is more convenient for both parties. Therefore, the open option of currency to use in trade has masked the effect of exchange rate volatility on container throughput. This could be another source of biases for this variable in container throughput context (Ethier, 1973).

Another macroeconomics variable tested in this study is the bilateral trade intensity index (TII). The use of this index as a determinant on container throughput is not considerably plenty yet. As far to the author knowledge, no study to date that use the exact bilateral TII on pure form of port container throughput. Vitsounis, Paflioti, & Tsamourgelis (2014) used the bilateral TII to assess port container throughput in the form of cross-correlation. Theoretically, as the bilateral trade between a country pair gets more intense, the volume of container handled through the port would increase since the bilateral trade is commonly facilitated through maritime transportation or shipping. Referring to Table 4.26, on average, the container throughput increases by 4.53% for every 1-point increase of bilateral trade intensity index (TII). Therefore, the hypothesis of a positive impact of TII on container throughput is proven.

Another issue regarding bilateral trade besides the intensity of the export import itself is the presence of free-trade agreement or free-trade area. Put simply, free-trade agreement means when "members of a preferential trading can go as far as to eliminate all tariffs and quantitative import restrictions among themselves" (Frankel, 1997). This preferential trading can be a region-based (e.g. ASEAN's free trade area) or non-regions (e.g. US-Singapore free-trade agreement). Countries that share a free-trade agreement or area, has better chance to increase the potential international trade between them. In terms of export, the presence of free-trade does increase the volume as Tenreyro (2006) has studied. According to the EGLS estimation result in the previous chapter, container throughput of port in a country that shares a free-trade agreement is smaller by 11.66%. This result deviates from the theory and it is even stranger considering even from the correlation matrix, the FTA variable has shown a weak and negative correlation with container throughput (-0.0127). Yet this condition is similar with previous studies that show a negative relationship (Tenreyro, 2006; Clark, Dollar, & Micco, 2004), but the trade agreement dummy is also insignificant in that research (Clark, Dollar, & Micco, 2004). The diversity of the sample may also explain the surprising negative sign of this variable. Moreover, this variable is similar with multimodal facility in terms of the binary value and lack of time-invariance among the country pairs.

### 5.4 Hypothesis Analysis: Fixed Effects

This subchapter consists of discussion and analysis of the hypotheses of port effects highlighting on the four major ports of Indonesia and the hypotheses of cluster effects.

The fixed effects mentioned in this case are referring to a set of dummy variables to represent the cross-sections wanted to be observed. To observe Indonesian port effects, the coefficient can be obtained through two approaches: adding fixed effects for all cross-sections or adding dummy variables indicating only the four cross-sections or ports of interest. The summary of the result can be seen in Table 5.2 below.

As can be seen, the decision to include fixed effects into the model has driven a varying result and deviation from the standard EGLS estimation. Some of the variables become unstable and turn its sign and/or significance. Therefore, it is best to keep in mind that the results should be interpreted with caution and it is suggested to have further analysis first. Despite the instability, the overall models are eligible to be analyzed further since their R-squared value is more than 90%. The high R-squared is achievable because fixed effects add more precision to the model. In terms of the changing significance, the turning of MM and TII into an insignificant variable in port fixed effects model is surprising. It is different compared with GDP or ER that has been slightly expected to be insignificant. Furthermore, more interesting part is from free-trade agreement variable that is now in positive relationship towards the container throughput as expected theoretically and hypothetically. The presence of free-trade agreement between country pair increase the container throughput by 1.1% higher than those who do not have. Another difference also spotted on the magnitude of LSBCI's coefficient that is not as large as the other results. A 0.01-point increase of LSBCI under port fixed effects in scenario 2 accounts for only 0.18% increase of container throughput now compared with other models that can increase by 3 to 3.4%.

For the Indonesia port effects itself, different models/scenarios represent various magnitude, but the sign and proportion between ports generate the same interpretation. In overall port effects of scenario 1, the container throughput in Belawan and Makassar Port is on average 39.8% and 92.9% smaller than the other ports respectively. Meanwhile, Tanjung Priok and Tanjung Perak Port is 68.5% and 41.3% higher than the other ports in the sample. These coefficient values are similar for Indonesia port effects model of scenario 1. In scenario 2 of overall port fixed effects, the coefficients are compared to a base category which is Tanjung Priok Port. Therefore, it can be interpreted that, on average, container throughputs of Tanjung Perak, Belawan, and Makassar Port are 40.4%, 124.6%, and 182.8% lower than the container throughput in Tanjung Priok. The similarity among these models of port effects is how the proportion and order remains the same. The highest container throughput volume is handled by Tanjung Priok Port followed by Tanjung Perak, Belawan, then lastly Makassar Port. This finding is in line with the data of container throughput in Indonesia as shown in the following figure.

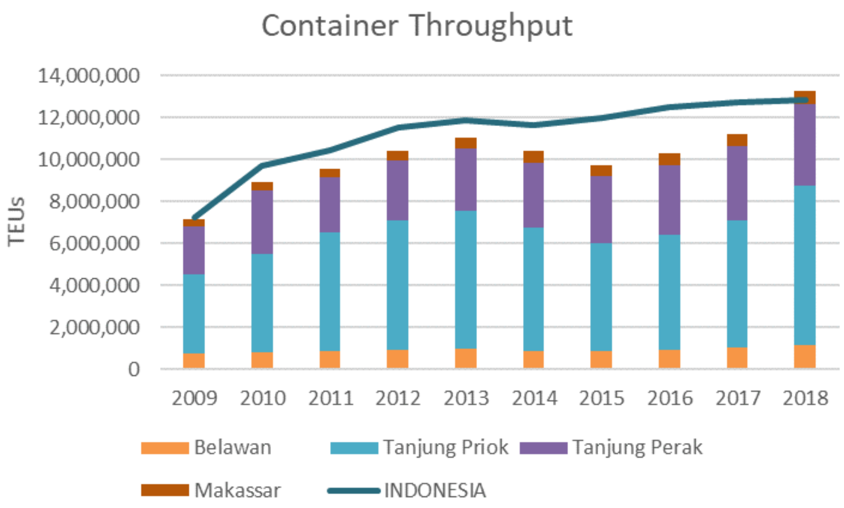


Figure 5.5 Container Throughput in Four Major Ports – Indonesia (2009—2018)

For the cluster-wise analysis, each scenario shares common independent variables which are GDP and exchange rate volatility. The exchange rate volatility remains insignificant in both models while the magnitude of GDP in scenario 1 is smaller than in scenario 2. For every one percent increase of GDP could increase the container throughput by 20.9% in scenario 1 and 42.7% in scenario 2. In the context of cluster effects, both scenario uses Asia as the reference category so the coefficient from the cluster effects will refer to Asian cluster. There are some interesting findings in this cluster effects. In scenario 1, the dummy variable representing Northern America cluster is declared insignificant above 10% level. It implies that the effect of a port container throughput being in a Northern America cluster is indecisive. However, the cluster then becomes significant at 1% level if scenario 2 is applied. In the scenario 2, ports in Europe have on average smaller container throughput by 97.2% compared with Asian ports. Meanwhile, for the Oceania and Northern America cluster, the average container throughput is lower by 117% and 133% respectively compared with Asian port cluster. The result is intriguing as they show how the proportion and order from the scenario 2 is different from the reality. It can be seen in the following figure that the container throughput of Northern America cluster is generally higher than the Oceania cluster. Yet, in this research there is no statistical evidence that can back this up.

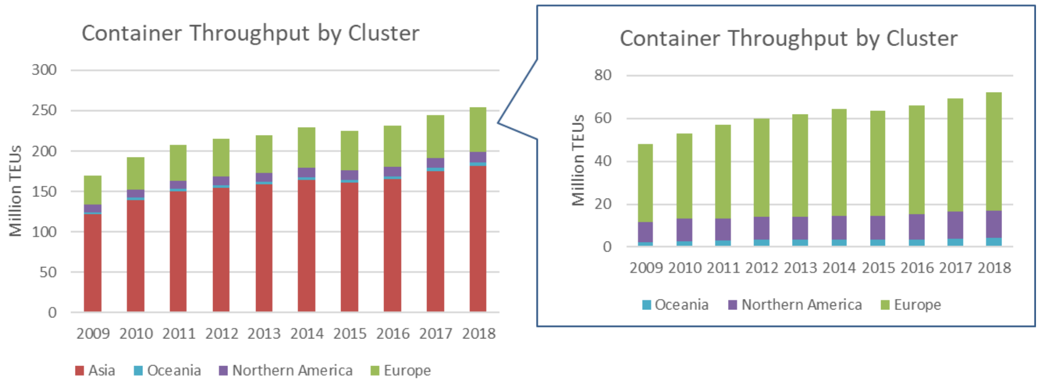


Figure 5.6 Container Throughput by Cluster (2009—2018)

Table 5.3 Summary of Port Effects and Cluster Effects from Scenario 1 and Scenario 2

| Explanatory variables | Coefficients | | | | | |
|---|---|---|---|---|---|---|
| | Port effects | | Indonesia port effects | | Cluster effects | |
| | S1 | S2 | S1 | S2 | S1 | S2 |
| C | 5.51 *** | 1.659 *** | 9.826 *** | 11.22 *** | 8.302 *** | 6.211 *** |
| PLSCI | 0.015 *** | | 0.029 *** | | 0.03 *** | |
| MM | 0.018 | | -0.313 *** | | -0.161 *** | |
| ln GDP | 0.328 *** | 0.518 *** | 0.153 *** | 0.212 *** | 0.209 *** | 0.427 *** |
| ER | 0.022 | -0.094 *** | -0.343 | -0.072 | 0.064 | 0.034 |
| ln GDP_J | | -0.003 | | -0.115 *** | | -0.125 *** |
| ER_J | | -0.007 | | 0.094 *** | | 0.064 ** |
| LSBCI | | 0.179 *** | | 3.263 *** | | 3.087 *** |
| TII | | -0.0011 | | 0.043 *** | | 0.029 *** |
| FTA | | 0.011 * | | -0.121 *** | | -0.183 *** |
| Indonesia port effects | | | | | | |
| Belawan | -0.398 *** | -1.246 *** | -0.284 *** | -0.858 *** | | |
| Makassar | -0.929 *** | -1.828 *** | -0.84 *** | -1.44 *** | | |
| Tanjung Perak | 0.413 *** | -0.404 *** | 0.432 *** | 0.216 *** | | |
| Tanjung Priok | 0.685 *** | Reference | 0.693 *** | 0.739 *** | | |
| Cluster effects | | | | | | |
| Asia | Reference category | | | | | |
| Europe | | | | | -0.497 *** | -0.972 *** |
| Northern America | | | | | 0.07 | -1.33 *** |
| Oceania | | | | | -0.324 *** | -1.17 *** |
| R-squared | 0.9917 | 0.9647 | 0.9736 | 0.9031 | 0.9415 | 0.9245 |

| **Explanatory variables** | **Coefficients** | | | | | |
|---|---|---|---|---|---|---|
| | **Port effects** | | **Indonesia port effects** | | **Cluster effects** | |
| | S1 | S2 | S1 | S2 | S1 | S2 |
| Prob. (F-statistic) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| * the corresponding variable is significant at 1% significance level; ** significance at 5% level; *** significance at 10% level | | | | | | |

Despite the varying results, the hypotheses of port effects and cluster effects can be proven that there is a significant effect in including port effects and cluster effects on container throughput. To sum up the analysis of the nine hypotheses in this research, Table 5.3 will provide the comparison between each hypothesis and the result obtained from the research.

Table 5.4 Summary of Hypotheses Analysis

| No | Category | Hypothesis | | | Result | |
|---|---|---|---|---|---|---|
| | | Code | Variable | Exp. Sign | Scenario 1 | Scenario 2 |
| 1 | Maritime logistics | H1 | PLSCI | + | + | |
| | | H2 | LSBCI | + | | + |
| | | H3 | MM | + | - | |
| 2 | Macroeconomics | H4 | GDP | + | + | + |
| | | H5 | TII | + | | + |
| | | H6 | ER | - | -* | -* |
| | | H7 | FTA | + | | - |
| 3 | Port effects | H8 | Tanjung Priok | There is a significant effect | + | + |
| | | | Tanjung Perak | | + | + |
| | | | Belawan | | - | - |
| | | | Makassar | | - | - |
| 4 | Cluster effects | H9 | Asia | There is a significant effect | reference | reference |
| | | | Northern America | | +* | - |
| | | | Oceania | | - | - |
| | | | Europe | | - | - |

*indicates the insignificant variable

## 5.5 Analysis on Interaction Effects of Indonesia's Four Major Ports

This subchapter consists of discussion and analysis of the interaction effects from the four major ports of Indonesia with the predetermined clusters (Asia, Europe, Trans-Pacific, and Oceania) and with the port partner to define potential partner for each Indonesian port.

### 5.5.1 Indonesian Ports on Predetermined Clusters

Discussing the issue of port container throughput, it is almost impossible not to touch the relationship that occurred with other ports. As been mentioned in the previous part that port container throughput is also influenced by the location or specifically on which region/cluster the port is located. In this analysis, there are four clusters that represent the busiest lane in maritime logistics—Mainlane East-West—in which Indonesia is also located. The four clusters namely, Asia, Europe, Oceania, and Northern America (Trans-Pacific). The previous subchapter already analyzed how each cluster is different in terms of their container throughput. In this section, the research question is expanded into how each port in Indonesia's sample is affected by these clusters.

It can be seen from Table 5.4 that there are some noticeable similarities in the interaction effect coefficients. For Tanjung Priok Port and Tanjung Perak Port the order of magnitude ascendingly is always started with Asia followed by Europe, Northern America, then Oceania. Meanwhile, Belawan and Makassar Port follow this order instead; Asia, Northern America, Europe, Oceania. In line with the previous subchapter's result, Tanjung Priok Port with any cluster leads larger container throughput among other ports in Indonesia. For instance, Tanjung Priok Port and Asian port cluster have a positive joint association of 72.5% with container throughput. Hence, in average, Tanjung Priok Port has 72.5% higher of container throughput when partnering with Asian port cluster. However, when Tanjung Priok Port is partnered with Oceania, the effect turns insignificant. Thus, the effect of joint association between Tanjung Priok Port and Oceania cluster on container throughput is statistically diminished. This insignificant variable implies that the result cannot be well interpreted since there is no evidence of an effect. In this case, the interactions are inconsistent at some points (or at certain year for the context in this research) in terms of its direction, positive or negative, thus it cancels out any effect bringing it to a net effect instead.

In the case of Belawan and Makassar, the negative sign can be interpreted as how their interactions with these clusters are below the average compared with the rest of the pairings. For instance, container throughput of Belawan with Europe cluster is on average lower by 60.2% compared with other pairings meanwhile, Tanjung Priok with Europe and Tanjung Perak with Europe have container throughput that is higher by 64.6% and 23% respectively than the other pairings. On the other hand, Makassar Port—that in general already produced lower throughput than the other—is also proven to have no outstanding interaction related to their cluster partners. Yet, one of the reasons why Makassar Port has higher interaction effect with Northern America as its partner is due to the direct call partnership with Los Angeles Port in 2018.

Overall, the strong relation between intra-Asia cluster is statistically proven here. Geographical advantages, easy access, economic and trade partnerships among Asian countries could be some of the many reasons behind these results. However, such traits which also can be found in Indonesia with Oceania cluster, the effect is not as grand as Asia because the trade intensity itself is considerably low. The traffic of container in Intra-Asia trade is also influenced immensely by the manufacturing relocations to developing countries in Asia. Therefore, it triggers growth in distributions and logistics through ports (Pelindo II, 2011).

Aside from the interpretations and analyses that have been discussed above, the result can also be implied as a means to observe which cluster that is best partnered with each port or how well the port performance (container throughput) of each port in response to shipping partner with different clusters. Take example of Tanjung Priok Port that has the lowest joint association with Oceania cluster among the four clusters. The port authority may response with establishing more deals with Oceanian ports that can increase the container traffic from and to that cluster. However, to decide which factor or aspect that is best to prioritize within each cluster is outside this research's scope. One can obtain such insight by modeling this issue with separate subsamples i.e. only do the regression with samples from Oceania cluster or more specific from the interaction between Tanjung Priok Port and Oceania cluster. Only then the critical aspects or factors for specific Tanjung Priok Port to notice can be proven statistically. More data points are required to get more meaningful results.

Table 5.5 Cluster Interaction Effects: Four Major Ports of Indonesia on Asia, Europe, Northern America, and Oceania

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| Methods: Panel EGLS (Cross-section weights) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| C | 11.1296 | 0.1517 | 73.3794 | 0.0000 |
| LSBCI | 3.5350 | 0.0343 | 102.9457 | 0.0000 |
| ln GDP_I | 0.2476 | 0.0036 | 68.0592 | 0.0000 |
| ln GDP_JE | -0.1529 | 0.0034 | -45.4449 | 0.0000 |
| ER_I | -0.0033 | 0.0558 | -0.0592 | 0.9528 |
| ER_JE | 0.0632 | 0.0327 | 1.9309 | 0.0535 |
| TII | 0.0413 | 0.0013 | 32.5228 | 0.0000 |
| FTA | -0.1474 | 0.0108 | -13.7033 | 0.0000 |
| *Interaction: Indonesia Ports*Cluster* | | | | |
| PRIOK*(CLUSTER="Asia") | 0.7250 | 0.0206 | 35.2594 | 0.0000 |
| PRIOK*(CLUSTER="Europe") | 0.6461 | 0.0267 | 24.2239 | 0.0000 |
| PRIOK*(CLUSTER="Northern America") | 0.4123 | 0.0869 | 4.7435 | 0.0000 |
| PRIOK*(CLUSTER="Oceania") | 0.0891 | 0.1089 | 0.8181 | 0.4133 |
| PERAK*(CLUSTER="Asia") | 0.4057 | 0.0196 | 20.7210 | 0.0000 |
| PERAK*(CLUSTER="Europe") | 0.2299 | 0.0174 | 13.2056 | 0.0000 |
| PERAK*(CLUSTER="Northern America") | 0.1461 | 0.0505 | 2.8942 | 0.0038 |
| PERAK*(CLUSTER="Oceania") | -0.1654 | 0.0739 | -2.2385 | 0.0252 |
| BEL*(CLUSTER="Asia") | -0.4075 | 0.0343 | -11.8695 | 0.0000 |
| BEL*(CLUSTER="Europe") | -0.6020 | 0.0204 | -29.4393 | 0.0000 |
| BEL*(CLUSTER="Northern America") | -0.4775 | 0.0258 | -18.5403 | 0.0000 |
| BEL*(CLUSTER="Oceania") | -0.7691 | 0.0328 | -23.4196 | 0.0000 |

| Explanatory variables | Coefficients | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| MKS*(CLUSTER="Asia") | -0.5869 | 0.0554 | -10.5874 | 0.0000 |
| MKS*(CLUSTER="Europe") | -0.8268 | 0.0379 | -21.8127 | 0.0000 |
| MKS*(CLUSTER="Northern America") | -0.7377 | 0.0633 | -11.6584 | 0.0000 |
| MKS*(CLUSTER="Oceania") | -1.1712 | 0.0523 | -22.3925 | 0.0000 |
| | | | | |
| R-squared | 0.8430 | | | |
| F-statistic | 1890.5300 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.1169 | | | |
| | | | | |
| Num. of cross-sections | 812 | | | |
| Num. of periods | 10 | | | |
| N | 8120 | | | |

### 5.5.2 Potential Port Partners

As the main gateway to international trade, it is important to assess how well the port performance is and aware of the competition as well as opportunities to collaborate or partner with other ports or countries. Hence, this analysis aims to delineate the potential partnership between Indonesian ports and other ports in the sample. The potential partners are assessed by sorting the coefficient of each interaction effect/variable according to its significance (probability or p-value) followed by its magnitude. The results are for each port are similar at some points and different at another.

Tanjung Priok Port is the main port and international hub of Indonesia. They established better connections with other ports overseas compared with the rest of three ports in Indonesia. On top of the list for Tanjung Priok Port is Shanghai which is also the case for Tanjung Perak. Shanghai as port partners will be a very beneficial opportunity as it is proven that their partnership is more than twice better compared with other pairings in the sample. There is also an interesting potential on the list which is Rotterdam Port that placed on 4$^{th}$ for Tanjung Priok Port and place 3$^{rd}$ for Tanjung Perak Port. The trade intensity with Netherlands is considerably more intense than with the other European country, thus it would be a leverage to have port partnership with Rotterdam. Same goes for Hamburg and Antwerp port that also pop up on the top 10 of the list.

For the case of Belawan Port, it serves mostly domestic shipping by 70% and the rest 30% are for international route or shipping. Despite its close proximity to strategic ports such as, Singapore and Port Klang, Malaysia, the proportion of service might be the reason why it has small to insignificant relationship with its neighboring ports. Moreover, Belawan's location is too far (not as strategic as Tanjung Priok or Tanjung Perak) for vessels to pool their containers. Belawan port rather benefits the most for maritime trade needs in its hinterland (North Sumatra, Aceh, Riau, and Kepulauan Riau). As the coefficients have shown, following Los Angeles Port for Belawan and Makassar, Tokyo and Algericas port enter the list as the top potential partner. However, Belawan Port might be pivoted for non-international shipping soon due to the plan to integrate a port near Belawan as the new international hub namely Kuala Tanjung Port that has been announced in 2019 by Directorate General of Marine Transportation (Direktorat Jenderal Perhubungan Laut, 2019).

In order to support the establishment of port partnership with other port overseas, the responsibility does not rely on the port authority alone; government should also play their part in integrating their National Strategic Plan with the port authorities and related institutions. In 2019 as well, Coordinating Ministry for Maritime and Investment Affairs stated that there will be seven ports to be transformed into international hub in which four of them are the ports of interest in this study. However, the statement itself got opposed by experts and practitioners. This is an example of unintegrated plan for ports to develop their international exposure. It is said so since creating plenty of hubs does not guarantee better growth of the port traffic. It is considered inefficient since it requires a large sum of investment costs. It will be more efficient if the economies of scale already been achieved. Meaning that the demand should be large enough for a port to be an international hub not to mention the infrastructure, capacity, and system that should be able to handle large vessels in large volume. Otherwise, it would be a waste of investment. Unintegrated hubs scattered across archipelagic country like Indonesia is currently seen as not a preferable plan. According to the President of Indonesian Logistics Association, Zaldy Ilham Masita, to execute such plans there should be at least a demand forecast for the routes that each port has, accessibility of area, and hinterland production and demand. This research could be one of the initial studies that can be further analyzed and developed to assess the port performance and gain insights on which port(s) to be approached as potential partners. Yet again in any case, as noted above, the limited number of observations in this sample, suggest that the results should be interpreted with caution and further analysis is required.

Table 5.6 Port Partner Interaction Effects: Tanjung Priok and Tanjung Perak on Port Partners

| Interaction effects | Coefficients | Interaction effects | Coefficients |
|---|---|---|---|
| PRIOK*(PORT="Shanghai") | 1.2636 *** | PERAK*(PORT="Shanghai") | 0.9545 *** |
| PRIOK*(PORT="Hongkong") | 1.0539 *** | PERAK*(PORT="Busan") | 0.7490 *** |
| PRIOK*(PORT="Busan") | 1.0448 *** | PERAK*(PORT="Rotterdam") | 0.6325 *** |
| PRIOK*(PORT="Rotterdam") | 0.9343 *** | PERAK*(PORT="Hamburg") | 0.4976 *** |
| PRIOK*(PORT="Singapore") | 0.9225 *** | PERAK*(PORT="Antwerp") | 0.4683 *** |
| PRIOK*(PORT="Hamburg") | 0.8233 *** | PERAK*(PORT="Los Angeles") | 0.3488 *** |
| PRIOK*(PORT="Antwerp") | 0.7731 *** | PERAK*(PORT="Laem Chabang") | 0.3166 *** |
| PRIOK*(PORT="Kaohsiung") | 0.7411 *** | PERAK*(PORT="Manila") | 0.2974 *** |
| PRIOK*(PORT="Manila") | 0.6659 *** | PERAK*(PORT="Piraeus") | 0.2052 *** |
| PRIOK*(PORT="Piraeus") | 0.6486 *** | PERAK*(PORT="Algericas") | 0.1944 *** |
| PRIOK*(PORT="Laem Chabang") | 0.6351 *** | PERAK*(PORT="Kaohsiung") | 0.4395 *** |
| PRIOK*(PORT="Los Angeles") | 0.6339 *** | PERAK*(PORT="Hongkong") | 0.7501 *** |
| PRIOK*(PORT="Ho Chi Minh City") | 0.6029 *** | PERAK*(PORT="Sihanoukville ") | -0.4152 *** |
| PRIOK*(PORT="Port Klang") | 0.5811 *** | PERAK*(PORT="Ho Chi Minh City") | 0.2940 *** |
| PRIOK*(PORT="Algericas") | 0.4765 *** | PERAK*(PORT="Tauranga") | -0.3653 *** |
| PRIOK*(PORT="Tokyo") | 0.4698 *** | PERAK*(PORT="Singapore") | 0.6231 ** |
| PRIOK*(PORT="Felixstowe") | 0.3287 ** | PERAK*(PORT="Tokyo") | 0.1906 ** |
| PRIOK*(PORT="Vancouver") | 0.3145 ** | PERAK*(PORT="Port Klang") | 0.2872 * |
| PRIOK*(PORT="Yangon") | 0.2860 * | | |
| PRIOK*(PORT="Melbourne") | 0.2482 * | | |

* the corresponding variable is significant at 1% significance level; ** significance at 5% level; *** significance at 10% level

Table 5.7 Port Partner Interaction Effects: Belawan and Makassar on Port Partners

| Interaction effects | Coefficients | Interaction effects | Coefficients |
|---|---|---|---|
| BEL*(PORT="Los Angeles") | -0.2915 *** | MKS*(PORT="Los Angeles") | -0.5465 *** |
| BEL*(PORT="Tokyo") | -0.4715 *** | MKS*(PORT="Tokyo") | -0.7450 *** |
| BEL*(PORT="Algericas") | -0.5918 *** | MKS*(PORT="Algericas") | -0.8387 *** |
| BEL*(PORT="Vancouver") | -0.6229 *** | MKS*(PORT="Felixstowe") | -0.8833 *** |
| BEL*(PORT="Felixstowe") | -0.6280 *** | MKS*(PORT="Vancouver") | -0.8946 *** |
| BEL*(PORT="Gdansk") | -0.6516 *** | MKS*(PORT="Gioia Tauro") | -0.9688 *** |
| BEL*(PORT="Gioia Tauro") | -0.6862 *** | MKS*(PORT="Melbourne") | -0.9728 *** |
| BEL*(PORT="Melbourne") | -0.6874 *** | MKS*(PORT="Piraeus") | -1.0521 *** |
| BEL*(PORT="Havre") | -0.7190 *** | MKS*(PORT="Havre") | -1.0646 *** |
| BEL*(PORT="Yangon") | -0.7344 *** | MKS*(PORT="Gdansk") | -1.1663*** |
| BEL*(PORT="Piraeus") | -0.7394 *** | MKS*(PORT="Yangon") | -1.2194 *** |
| BEL*(PORT="Tauranga") | -0.9696 *** | MKS*(PORT="Tauranga") | -1.3967 *** |
| BEL*(PORT="Sihanoukville ") | -1.0299 *** | MKS*(PORT="Sihanoukville ") | -1.4196 *** |
| BEL*(PORT="Manila") | -0.2804 ** | MKS*(PORT="Manila") | -0.5575 *** |
| | | MKS*(PORT="Laem Chabang") | -0.5434 ** |
| | | MKS*(PORT="Ho Chi Minh City") | -0.5726 ** |
| | | MKS*(PORT="Hamburg") | -0.3912 ** |
| | | MKS*(PORT="Port Klang") | -0.5765 * |

* the corresponding variable is significant at 1% significance level; ** significance at 5% level; *** significance at 10% level

# CHAPTER 6
# CONCLUSIONS AND RECOMMENDATIONS

This chapter contains conclusions of this research referring to the objectives stated in the beginning. The recommendations for future researches will also be included in this chapter.

## 6.1 Conclusions

1. The panel regression estimation that can describe the relation between maritime logistics and macroeconomics factors towards the port container throughput is obtained through panel estimated generalized least squares (EGLS) with cross-section weights. There are two form of estimators: scenario 1 for port as individuals and scenario 2 for port as pairs. The models are presented in the following equations.

   Scenario 1:

$$\begin{aligned}\ln CT_{it} = 9.2071 + 0.0298\ PLSCI_{it} - 0.3573\ MM_{it} \\ + \ln 0.175\ \ GDP_{it} + u_{it}\end{aligned} \tag{6.1}$$

   Scenario 2

$$\begin{aligned}ln\ CT_{it} = 10.4802 + 3.4355\ LSBCI_{ijt} + \ln 0.2565\ \ GDP_{it} \\ - \ln 0.1369\ \ GDP_{jt} + 0.0453\ TII_{ijt} \\ - 0.1166\ FTA_{ijt} + u_{it}\end{aligned} \tag{6.2}$$

2. The interdependency between maritime logistics and macroeconomics factor towards the port container throughput are varying. From the maritime logistics aspect, Port Liner Shipping Connectivity Index (PLSCI) and Liner Shipping Bilateral Connectivity Index (LSBCI) have positive effects on container throughput which is aligned with the hypothesis and theory. For the presence of multimodal facility (MM), it influences container throughput negatively which contradicts with the theory and the hypothesis.

In terms of macroeconomics, gross domestic product of the respected port (GDP) affects container throughput positively, be it analyzed in individual port level or port-pair level. Bilateral trade intensity index (TII) also shows positive influence on container throughput. However, the exchange rate volatility (ER) and the presence of free-trade agreements between the country-pair (FTA) are contradictive with the hypothesis. The explanatory power of ER is diminished due to its insignificant as a determinant, yet it actually aligns with the theory and previous researches that often find its insignificant. Meanwhile, the FTA has shown negative impact on container throughput whereas it should have been positive theoretically.

3. The most critical variable that influence the container throughput significantly is gross domestic product (GDP) of the port's country followed by bilateral trade intensity index (TII) and connectivity indices which are the Port Liner Shipping Connectivity Index (PLSCI) and Liner Shipping Bilateral Connectivity Index (LSBCI).
4. The cluster that has the most contribution to container throughput in four major ports of Indonesia is Asia. On the other hand, Oceanian cluster has the least contribution to the four major ports of Indonesia. For the second and third position, Europe and Northern America cluster are in turn changing their position. Europe's influence as the second most contributor is incurred during its interaction with Tanjung Priok and Tanjung Perak Port. Belawan and Makassar Port got Northern America as their second best cluster partner.
5. The top 5 potential port partners for Tanjung Priok Port are Shanghai Port, Hongkong Port, Busan Port, Rotterdam Port, and Singapore Port. For Tanjung Perak Port, the number one potential partners that increase the container throughput is also Shanghai Port, followed by Busan Port, Rotterdam Port, Hamburg Port, and Antwerp Port. On the contrary, the top 5 interaction effects on Belawan and Makassar Port are similar only a switch of place between the fourth and fifth place for each of those two

ports. There are Los Angeles Port, Tokyo Port, Algericas Port, Felixstowe Port, and Vancouver Port.

## 6.2 Recommendations

This research could be one of the initial studies that can be further analyzed and developed to assess the port performance and gain insights on container throughput and its determinants as well as the identification of potential port partners. Due to the limitations in this study, the author suggests that the results should be interpreted with caution and further analysis is required. Further studies are recommended to do the following activities:

1. Include more data points, samples, periods, and variables to enhance the model reliability and reduce the overall biases.
2. Try to regress the variables in separate subsamples (e.g. cluster-based), thus the effect of variables in different subsamples can be observed in terms how the magnitude and sign of the coefficient differs or how the significance of the same variable in each subsample varies.
3. Accommodate the component breakdown of connectivity indices and/or internal performance indicators of port into an independent variable to obtain more insights on internal factors and logistics factor on port container throughput.
4. Explore variables that minimize the indirect ties with the dependent variable (e.g. the dependent variable is in port level, yet the independent variables are mostly in country level whereas there are several ports included in one country).
5. Divide the data points obtained into half: use the first couple periods for modelling and the rest of the period data for analysis as well as matching the result from the obtained model.

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# ATTACHMENTS

### *Descriptive Statistics*

Attachment 1 Scenario 1 Variables

| | ln CT | PLSCI | MM | ln GDP | ER |
|---|---|---|---|---|---|
| Mean | 15.2052 | 50.3575 | 0.7310 | 27.1545 | 0.0256 |
| Median | 15.2723 | 42.3071 | 1 | 26.9192 | 0.0152 |
| Maximum | 17.5534 | 133.5827 | 1 | 30.6554 | 1.3452 |
| Minimum | 12.0057 | 3.6163 | 0 | 23.0653 | 0 |
| Std. Dev. | 1.2271 | 33.2231 | 0.4442 | 1.5161 | 0.1077 |
| Skewness | -0.3593 | 0.6397 | -1.0421 | 0.0335 | 11.1698 |
| Kurtosis | 2.6426 | 2.3955 | 2.0859 | 3.0479 | 129.9679 |
| | | | | | |
| Jarque-Bera | 7.7842 | 24.195 | 62.5810 | 0.0820 | 200823.8 |
| Probability | 0.0204 | 0.000006 | 0 | 0.9598 | 0 |
| | | | | | |
| Sum | 4409.502 | 14603.67 | 212 | 7874.794 | 7.4331 |
| Sum Sq. Dev. | 435.1757 | 318990.7 | 57.02069 | 664.2993 | 3.3511 |
| | | | | | |
| Observations | 290 | 290 | 290 | 290 | 290 |

Attachment 2 Scenario 2 Variables

| | ln CT | LSBCI | ln GDP_I | ln GDP_J | ER_I | ER_J | TII | FTA |
|---|---|---|---|---|---|---|---|---|
| Mean | 15.205 | 0.429 | 27.154 | 27.154 | 0.026 | 0.026 | 1.164 | 0.383 |
| Median | 15.272 | 0.407 | 26.919 | 26.919 | 0.015 | 0.015 | 0.281 | 0 |
| Maximum | 17.553 | 0.856 | 30.655 | 30.655 | 1.345 | 1.345 | 62.272 | 1 |
| Minimum | 12.006 | 0 | 23.065 | 23.065 | 0 | 0 | 0 | 0 |
| Std. Dev. | 1.225 | 0.160 | 1.514 | 1.514 | 0.108 | 0.108 | 3.258 | 0.486 |
| Skewness | -0.359 | 0.185 | 0.034 | 0.034 | 11.170 | 11.170 | 7.610 | 0.480 |
| Kurtosis | 2.643 | 2.803 | 3.048 | 3.048 | 129.968 | 129.968 | 84.607 | 1.231 |
| | | | | | | | | |
| Jarque-Bera | 217.96 | 59.360 | 2.295 | 2.295 | 5623065 | 5623065 | 2331600 | 1371.3 |
| Probability | 0 | 0 | 0.317 | 0.317 | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| Sum | 123466.1 | 3482.1 | 220494.2 | 220494.2 | 208.1 | 208.1 | 9448.1 | 3112.0 |
| Sum Sq. Dev. | 12184.9 | 208.0 | 18600.4 | 18600.4 | 93.8 | 93.8 | 86180.2 | 1919.3 |
| | | | | | | | | |
| Observations | 8120 | 8120 | 8120 | 8120 | 8120 | 8120 | 8120 | 8120 |

Attachment 3 Container Throughput

| | **Mean** | **Median** | **Max** | **Min.** | **Std. Dev.** | **Obs.** |
|---|---|---|---|---|---|---|
| **CLUSTER** | | | | | | |
| Asia | 9,826,354.0 | 5,412,347.0 | 42,010,000.0 | 163,692.0 | 10,691,864.0 | 160 |
| Europe | 5,220,512.0 | 3,735,000.0 | 14,510,000.0 | 240,623.0 | 3,702,662.0 | 90 |
| Northern America | 5,572,900.0 | 5,330,500.0 | 9,460,000.0 | 2,152,000.0 | 2,874,358.0 | 20 |

| | Mean | Median | Max | Min. | Std. Dev. | Obs. |
|---|---|---|---|---|---|---|
| Oceania | 1,651,772.0 | 1,491,758.0 | 2,929,294.0 | 511,343.0 | 898,092.4 | 20 |
| All | 7,539,849.0 | 4,292,000.0 | 42,010,000.0 | 163,692.0 | 8,657,278.0 | 290 |

| PORT | | | | | | |
|---|---|---|---|---|---|---|
| Algericas | 4,106,900.0 | 4,445,000.0 | 4,770,000.0 | 2,810,000.0 | 710,773.7 | 10 |
| Antwerp | 9,187,200.0 | 8,822,000.0 | 11,100,000.0 | 7,309,000.0 | 1,117,275.0 | 10 |
| Belawan | 894,157.0 | 879,869.5 | 1,128,913.0 | 718,663.0 | 114,766.1 | 10 |
| Busan | 17,714,900.0 | 18,169,500.0 | 21,660,000.0 | 11,980,000.0 | 2,979,986.0 | 10 |
| Felixstowe | 3,733,000.0 | 3,740,000.0 | 4,300,000.0 | 3,100,000.0 | 359,754.5 | 10 |
| Gdansk | 1,067,678.0 | 1,134,413.0 | 1,948,974.0 | 240,623.0 | 503,872.8 | 10 |
| Gioia Tauro | 2,691,500.0 | 2,759,000.0 | 3,087,000.0 | 2,305,000.0 | 270,628.2 | 10 |
| Hamburg | 8,716,200.0 | 8,861,500.0 | 9,730,000.0 | 7,007,000.0 | 756,754.6 | 10 |
| Havre | 2,491,627.0 | 2,482,054.0 | 2,884,000.0 | 2,180,328.0 | 251,097.1 | 10 |
| Ho Chi Minh City | 5,301,600.0 | 5,426,000.0 | 6,390,000.0 | 3,563,000.0 | 995,460.2 | 10 |
| Hongkong | 21,707,800.0 | 21,635,000.0 | 24,400,000.0 | 19,600,000.0 | 1,698,283.0 | 10 |
| Kaohsiung | 9,914,600.0 | 10,098,500.0 | 10,590,000.0 | 8,581,000.0 | 641,050.9 | 10 |
| Laem Chabang | 6,366,700.0 | 6,305,500.0 | 8,070,000.0 | 4,537,000.0 | 1,141,005.0 | 10 |
| Los Angeles | 8,321,700.0 | 8,118,500.0 | 9,460,000.0 | 7,261,000.0 | 716,265.5 | 10 |
| Makassar | 502,856.5 | 536,944.1 | 629,659.2 | 355,507.2 | 93,090.2 | 10 |
| Manila | 3,924,000.0 | 3,737,500.0 | 5,050,000.0 | 2,874,000.0 | 712,627.8 | 10 |
| Melbourne | 2,489,982.0 | 2,556,231.0 | 2,929,294.0 | 1,801,368.0 | 302,591.2 | 10 |
| Piraeus | 2,850,500.0 | 3,266,500.0 | 4,910,000.0 | 513,000.0 | 1,462,195.0 | 10 |
| Port Klang | 10,822,200.0 | 10,650,000.0 | 13,730,000.0 | 7,309,000.0 | 2,001,340.0 | 10 |
| Rotterdam | 12,140,000.0 | 12,053,000.0 | 14,510,000.0 | 9,743,000.0 | 1,307,526.0 | 10 |

| | Mean | Median | Max | Min. | Std. Dev. | Obs. |
|---|---|---|---|---|---|---|
| Shanghai | 34,311,500.0 | 34,453,500.0 | 42,010,000.0 | 25,000,000.0 | 5,086,262.0 | 10 |
| Sihanoukville | 334,468.6 | 310,952.0 | 541,228.0 | 210,500.0 | 111,135.4 | 10 |
| Singapore | 31,408,300.0 | 31,284,500.0 | 36,600,000.0 | 25,866,000.0 | 3,002,251.0 | 10 |
| Tanjung Perak | 3,079,941.0 | 3,068,000.0 | 3,865,646.0 | 2,270,000.0 | 449,408.1 | 10 |
| Tanjung Priok | 5,730,281.0 | 5,774,500.0 | 7,640,000.0 | 3,804,000.0 | 1,045,704.0 | 10 |
| Tauranga | 813,561.1 | 823,565.0 | 1,182,147.0 | 511,343.0 | 223,317.3 | 10 |
| Tokyo | 4,518,400.0 | 4,600,000.0 | 4,890,000.0 | 3,810,000.0 | 327,904.5 | 10 |
| Vancouver | 2,824,100.0 | 2,867,500.0 | 3,400,000.0 | 2,152,000.0 | 371,399.0 | 10 |
| Yangon | 689,956.0 | 642,041.0 | 1,288,000.0 | 163,692.0 | 370,463.1 | 10 |
| All | 7,539,849.0 | 4,292,000.0 | 42,010,000.0 | 163,692.0 | 8,657,278.0 | 290 |

***Estimator(s) Result Summary***

**Scenario 1**

Attachment 4 Fixed Effects Summary

| **Port effects** | | | | |
|---|---|---|---|---|
| **Explanatory variables** | **Coefficients** | **Std. Error** | **t-Statistic** | **Probability** |
| Methods: Panel EGLS (Cross-section weights) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | 5.5100 | 0.6836 | 8.0602 | 0.0000 |
| PLSCI | 0.0154 | 0.0012 | 12.4873 | 0.0000 |
| MM | 0.0185 | 0.0379 | 0.4871 | 0.6266 |
| ln GDP | 0.3280 | 0.0259 | 12.6496 | 0.0000 |
| ER | 0.0221 | 0.0739 | 0.2987 | 0.7654 |
| | | | | |
| R-squared | 0.9917 | | | |
| F-statistic | 954.3110 | | | |
| Prob. (F-statistic) | 0.0000 | | | |
| Durbin-Watson stat | 0.9058 | | | |
| | | | | |
| Num. of cross-sections | 29 | | | |
| Num. of periods | 10 | | | |
| N | 290 | | | |
| | | | | |
| *Port effects* | | | | |
| Algericas | -0.2505 | | | |
| Antwerp | 0.2952 | | | |
| Belawan | -0.3976 | | | |
| Busan | 0.4417 | | | |
| Felixstowe | -0.5817 | | | |
| Gdansk | -1.1510 | | | |
| Gioia Tauro | -0.6233 | | | |
| Hamburg | -0.1947 | | | |
| Havre | -1.0328 | | | |
| Ho Chi Minh City | 0.9840 | | | |
| Hongkong | 1.0788 | | | |
| Kaohsiung | 0.7376 | | | |
| Laem Chabang | 0.7395 | | | |
| Los Angeles | -0.1601 | | | |
| Makassar | -0.9290 | | | |
| Manila | 0.6410 | | | |

| Port effects | | | | |
|---|---|---|---|---|
| **Explanatory variables** | **Coefficients** | **Std. Error** | **t-Statistic** | **Probability** |
| Melbourne | -0.3806 | | | |
| Piraeus | -0.1076 | | | |
| Port Klang | 0.7615 | | | |
| Rotterdam | 0.4130 | | | |
| Shanghai | 0.1709 | | | |
| Sihanoukville | -0.6582 | | | |
| Singapore | 1.3257 | | | |
| Tanjung Perak | 0.4129 | | | |
| Tanjung Priok | 0.6846 | | | |
| Tauranga | -0.7783 | | | |
| Tokyo | -0.5528 | | | |
| Vancouver | -0.3953 | | | |
| Yangon | -0.4931 | | | |

## Scenario 2

Attachment 5 Fixed Effects Summary (PORT_I)

| Port effects | | | | |
|---|---|---|---|---|
| **Explanatory variables** | **Coefficients** | **Std. Error** | **t-Statistic** | **Probability** |
| Methods: Panel EGLS (Cross-section weights) | | | | |
| Dependent variable: Container throughput (ln CT) | | | | |
| | | | | |
| C | 1.6595 | 0.3514 | 4.7225 | 0.0000 |
| LSBCI | 0.1790 | 0.0270 | 6.6372 | 0.0000 |
| ln GDP_I | 0.5177 | 0.0130 | 39.7314 | 0.0000 |
| ln GDP_JE | -0.0026 | 0.0022 | -1.1372 | 0.2555 |
| ER_I | -0.0935 | 0.0253 | -3.6937 | 0.0002 |
| ER_JE | -0.0071 | 0.0239 | -0.2984 | 0.7654 |
| TII | -0.0011 | 0.0009 | -1.2435 | 0.2137 |
| FTA | 0.0111 | 0.0059 | 1.8849 | 0.0595 |
| *Port effects* | | | | |
| PORT_I="Algericas" | -0.9303 | 0.0248 | -37.5426 | 0.0000 |
| PORT_I="Antwerp" | 0.3968 | 0.0203 | 19.5162 | 0.0000 |
| PORT_I="Belawan" | -1.2461 | 0.0247 | -50.4602 | 0.0000 |
| PORT_I="Busan" | 0.5242 | 0.0247 | 21.2121 | 0.0000 |
| PORT_I="Felixstowe" | -1.3777 | 0.0310 | -44.4428 | 0.0000 |
| PORT_I="Gdansk" | -1.8602 | 0.0196 | -95.0693 | 0.0000 |
| PORT_I="Gioia Tauro" | -1.5573 | 0.0282 | -55.1459 | 0.0000 |
| PORT_I="Hamburg" | -0.6736 | 0.0338 | -19.9176 | 0.0000 |

| Port effects | | | | |
|---|---|---|---|---|
| **Explanatory variables** | **Coefficients** | **Std. Error** | **t-Statistic** | **Probability** |
| PORT_I="Havre" | -1.7719 | 0.0308 | -57.5732 | 0.0000 |
| PORT_I="Ho Chi Minh City" | 0.4218 | 0.0236 | 17.8850 | 0.0000 |
| PORT_I="Hongkong" | 1.5605 | 0.0215 | 72.7078 | 0.0000 |
| PORT_I="Kaohsiung" | 0.4997 | 0.0206 | 24.2683 | 0.0000 |
| PORT_I="Laem Chabang" | 0.1666 | 0.0197 | 8.4489 | 0.0000 |
| PORT_I="Los Angeles" | -1.5250 | 0.0517 | -29.5211 | 0.0000 |
| PORT_I="Makassar" | -1.8276 | 0.0248 | -73.8411 | 0.0000 |
| PORT_I="Manila" | -0.1095 | 0.0207 | -5.3007 | 0.0000 |
| PORT_I="Melbourne" | -1.3899 | 0.0240 | -57.9234 | 0.0000 |
| PORT_I="Piraeus" | -0.5705 | 0.0213 | -26.8330 | 0.0000 |
| PORT_I="Port Klang" | 0.8185 | 0.0210 | 39.0244 | 0.0000 |
| PORT_I="Rotterdam" | 0.4040 | 0.0219 | 18.4663 | 0.0000 |
| PORT_I="Shanghai" | 0.1928 | 0.0443 | 4.3541 | 0.0000 |
| PORT_I="Sihanoukville" | -1.1212 | 0.0480 | -23.3454 | 0.0000 |
| PORT_I="Singapore" | 1.9040 | 0.0213 | 89.2773 | 0.0000 |
| PORT_I="Tanjung Perak" | -0.4037 | 0.0202 | -19.9917 | 0.0000 |
| PORT_I="Tanjung Priok" | Reference category | | | |
| PORT_I="Tauranga" | -1.5112 | 0.0375 | -40.2572 | 0.0000 |
| PORT_I="Tokyo" | -1.3841 | 0.0261 | -52.9626 | 0.0000 |
| PORT_I="Vancouver" | -1.1842 | 0.0331 | -35.7303 | 0.0000 |
| PORT_I="Yangon" | 0.7749 | 0.0965 | 8.0292 | 0.0000 |
| | | | | |
| R-squared | 0.9647 | | | |
| Durbin-Watson stat | 0.3408 | | | |
| | | | | |
| Num. of cross-sections | 812 | | | |
| Num. of periods | 10 | | | |
| N | 8120 | | | |

## *Running Model with EViews 10*

Attachment 6 Autocorrelation Test Steps: Regression on Lagged-1 Period (left), Wooldridge Test (right)

Dependent Variable: RESIDS1
Method: Panel Least Squares
Date: 07/28/20 Time: 23:36
Sample: 1 290 IF CELLID=2
Periods included: 1
Cross-sections included: 29
Total panel (balanced) observations: 29

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LAG1RESID | 0.866912 | 0.050337 | 17.22201 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.913475 | Mean dependent var | -0.032359 |
| Adjusted R-squared | 0.913475 | S.D. dependent var | 0.594955 |
| S.E. of regression | 0.175007 | Akaike info criterion | -0.614110 |
| Sum squared resid | 0.857566 | Schwarz criterion | -0.566962 |
| Log likelihood | 9.904597 | Hannan-Quinn criter. | -0.599344 |
| Durbin-Watson stat | 0.000000 | | |

Wald Test:
Equation: WOOLDRIDGE

| Test Statistic | Value | df | Probability |
|---|---|---|---|
| t-statistic | 27.15498 | 28 | 0.0000 |
| F-statistic | 737.3927 | (1, 28) | 0.0000 |
| Chi-square | 737.3927 | 1 | 0.0000 |

Null Hypothesis: C(1)=-0.5
Null Hypothesis Summary:

| Normalized Restriction (= 0) | Value | Std. Err. |
|---|---|---|
| 0.5 + C(1) | 1.366912 | 0.050337 |

Restrictions are linear in coefficients.

Attachment 7 Panel EGLS with Cross-Section Weights Summary: Scenario 1 (left), Scenario 2 (right)

Dependent Variable: LOG(CT)
Method: Panel EGLS (Cross-section weights)
Date: 07/28/20 Time: 19:10
Sample: 1 290
Periods included: 10
Cross-sections included: 29
Total panel (balanced) observations: 290
Linear estimation after one-step weighting matrix
Cross-section weights (PCSE) standard errors & covariance (no d.f. correction)

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 9.207121 | 0.441362 | 20.86071 | 0.0000 |
| PLSCI | 0.029796 | 0.000465 | 64.06623 | 0.0000 |
| MM | -0.357325 | 0.051112 | -6.991080 | 0.0000 |
| LOG(GDP) | 0.175030 | 0.016519 | 10.59596 | 0.0000 |
| ER | -0.123051 | 0.366556 | -0.335694 | 0.7373 |

Weighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.934430 | Mean dependent var | 26.82556 |
| Adjusted R-squared | 0.933509 | S.D. dependent var | 19.92453 |
| S.E. of regression | 0.523961 | Sum squared resid | 78.24255 |
| F-statistic | 1015.368 | Durbin-Watson stat | 0.291134 |
| Prob(F-statistic) | 0.000000 | | |

Unweighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.813597 | Mean dependent var | 15.20518 |
| Sum squared resid | 81.11787 | Durbin-Watson stat | 0.107915 |

Dependent Variable: LOG_CT
Method: Panel EGLS (Cross-section weights)
Date: 07/29/20 Time: 11:45
Sample: 1 8120
Periods included: 10
Cross-sections included: 812
Total panel (balanced) observations: 8120
Linear estimation after one-step weighting matrix
Cross-section weights (PCSE) standard errors & covariance (no d.f. correction)

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 10.48019 | 0.149150 | 70.26598 | 0.0000 |
| LSBCI | 3.435505 | 0.034301 | 100.1575 | 0.0000 |
| LOG_GDP_I | 0.256488 | 0.003429 | 74.80867 | 0.0000 |
| LOG_GDP_JE | -0.136855 | 0.003821 | -35.81266 | 0.0000 |
| ER_I | -0.060773 | 0.058183 | -1.044517 | 0.2963 |
| ER_JE | 0.051875 | 0.037248 | 1.392705 | 0.1637 |
| TII | 45.26970 | 1.303295 | 34.73481 | 0.0000 |
| FTA | -0.116561 | 0.009475 | -12.30246 | 0.0000 |

Weighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.770027 | Mean dependent var | 26.01120 |
| Adjusted R-squared | 0.769828 | S.D. dependent var | 25.92160 |
| S.E. of regression | 0.933436 | Sum squared resid | 7068.012 |
| F-statistic | 3880.235 | Durbin-Watson stat | 0.097684 |
| Prob(F-statistic) | 0.000000 | | |

Unweighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.415172 | Mean dependent var | 15.20518 |
| Sum squared resid | 7126.088 | Durbin-Watson stat | 0.029008 |

## Attachment 8 Hausman Test: Scenario 1 (left), Scenario 2 (right)

Correlated Random Effects - Hausman Test
Equation: S1_POLS
Test cross-section random effects

| Test Summary | Chi-Sq. Statistic | Chi-Sq. d.f. | Prob. |
|---|---|---|---|
| Cross-section random | 0.000000 | 4 | 1.0000 |

* Cross-section test variance is invalid. Hausman statistic set to zero.
** WARNING: robust standard errors may not be consistent with assumptions of Hausman test variance calculation.

Cross-section random effects test comparisons:

| Variable | Fixed | Random | Var(Diff.) | Prob. |
|---|---|---|---|---|
| PLSCI | 0.023823 | 0.025912 | -0.000003 | NA |
| MM | 0.094246 | 0.046152 | 0.001490 | 0.2127 |
| LOG(GDP) | 0.272470 | 0.217594 | 0.000954 | 0.0757 |
| ER | -0.049551 | -0.045720 | -0.006032 | NA |

Correlated Random Effects - Hausman Test
Equation: S2_REM
Test cross-section random effects

| Test Summary | Chi-Sq. Statistic | Chi-Sq. d.f. | Prob. |
|---|---|---|---|
| Cross-section random | 437.213489 | 7 | 0.0000 |

Cross-section random effects test comparisons:

| Variable | Fixed | Random | Var(Diff.) | Prob. |
|---|---|---|---|---|
| LSBCI | 2.758189 | 2.659354 | 0.000708 | 0.0002 |
| LOG_GDP_I | 0.283227 | 0.333375 | 0.000056 | 0.0000 |
| LOG_GDP_JE | 0.384568 | 0.247943 | 0.000056 | 0.0000 |
| ER_I | -0.056820 | -0.058859 | 0.000001 | 0.0040 |
| ER_JE | 0.019981 | 0.019340 | 0.000000 | 0.3616 |
| TII | 13.772464 | 18.261019 | 1.069781 | 0.0000 |
| FTA | 0.057193 | 0.084469 | 0.000019 | 0.0000 |

## Attachment 9 Interaction Effects Port x Cluster

Dependent Variable: LOG_CT
Method: Panel EGLS (Cross-section weights)
Date: 07/29/20 Time: 23:27
Sample: 1 8120
Periods included: 10
Cross-sections included: 812
Total panel (balanced) observations: 8120
Linear estimation after one-step weighting matrix
Cross-section weights (PCSE) standard errors & covariance (no d.f. correction)

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 11.12957 | 0.151672 | 73.37942 | 0.0000 |
| LSBCI | 3.535031 | 0.034339 | 102.9457 | 0.0000 |
| LOG_GDP_I | 0.247554 | 0.003637 | 68.05922 | 0.0000 |
| LOG_GDP_JE | -0.152920 | 0.003365 | -45.44493 | 0.0000 |
| ER_I | -0.003300 | 0.055771 | -0.059167 | 0.9528 |
| ER_JE | 0.063156 | 0.032709 | 1.930870 | 0.0535 |
| TII | 41.34907 | 1.271385 | 32.52284 | 0.0000 |
| FTA | -0.147434 | 0.010759 | -13.70325 | 0.0000 |
| PRIOK*(INICLUSTER="Asia") | 0.724986 | 0.020561 | 35.25940 | 0.0000 |
| PRIOK*(INICLUSTER="Europe") | 0.646133 | 0.026673 | 24.22388 | 0.0000 |
| PRIOK*(INICLUSTER="Northern America") | 0.412261 | 0.086911 | 4.743500 | 0.0000 |
| PRIOK*(INICLUSTER="Oceania") | 0.089066 | 0.108869 | 0.818099 | 0.4133 |
| PERAK*(INICLUSTER="Asia") | 0.405660 | 0.019577 | 20.72102 | 0.0000 |
| PERAK*(INICLUSTER="Europe") | 0.229918 | 0.017411 | 13.20556 | 0.0000 |
| PERAK*(INICLUSTER="Northern America") | 0.146146 | 0.050496 | 2.894211 | 0.0038 |
| PERAK*(INICLUSTER="Oceania") | -0.165370 | 0.073874 | -2.238531 | 0.0252 |
| BEL*(INICLUSTER="Asia") | -0.407536 | 0.034335 | -11.86953 | 0.0000 |
| BEL*(INICLUSTER="Europe") | -0.601990 | 0.020448 | -29.43934 | 0.0000 |
| BEL*(INICLUSTER="Northern America") | -0.477541 | 0.025757 | -18.54027 | 0.0000 |
| BEL*(INICLUSTER="Oceania") | -0.769142 | 0.032842 | -23.41956 | 0.0000 |
| MKS*(INICLUSTER="Asia") | -0.586922 | 0.055436 | -10.58742 | 0.0000 |
| MKS*(INICLUSTER="Europe") | -0.826837 | 0.037906 | -21.81269 | 0.0000 |
| MKS*(INICLUSTER="Northern America") | -0.737736 | 0.063279 | -11.65841 | 0.0000 |
| MKS*(INICLUSTER="Oceania") | -1.171152 | 0.052301 | -22.39251 | 0.0000 |

Weighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.843034 | Mean dependent var | 27.15967 |
| Adjusted R-squared | 0.842588 | S.D. dependent var | 25.34289 |
| S.E. of regression | 0.892584 | Sum squared resid | 6450.128 |
| F-statistic | 1890.530 | Durbin-Watson stat | 0.116876 |
| Prob(F-statistic) | 0.000000 | | |

Unweighted Statistics

| | | | |
|---|---|---|---|
| R-squared | 0.452533 | Mean dependent var | 15.20518 |
| Sum squared resid | 6670.841 | Durbin-Watson stat | 0.031801 |

# AUTHOR'S BIOGRAPHY


The author was born on October 21st, 1998, in Jakarta with a full name of Roudhotul Sofa Nurau**liya**. The author is the only daughter and the youngest from three siblings. She studied in Al-Falah Klender, Jakarta since her elementary until middle school. Then she continued her high school in SMAN 71 Jakarta. In 2016, the author accepted in Industrial Engineering Department of Institut Teknologi Sepuluh Nopember, Surabaya.

Throughout the college life, the author was actively involved in various activities and organizations. Some of the highlights of her organizations journey are: in Industrial Engineering Student Association of ITS (HMTI ITS) from 2017 – 2019 as Staff in Student Resource Development and continued as Head of Mapping and Controlling Bureau in the same department; in AIESEC Surabaya from 2019 – 2020 as Talent Analysis Manager in Talent Management function; in Logistics and Supply Chain Management (LSCM) Laboratory as Laboratory Assistant since late 2018 until her graduation. In 2018, she went to Turkey as one of the ITS delegates for Delightful Istanbul Winter School. She is also an awardee of a merit-based scholarship, XL Future Leaders Batch 7, in which she leads an Internet-of-Things-based social innovation project with her teammates.

The author also had an experience of internship in Adaro Logistics from July – August 2019 as Logistics Planning Intern. Since July 2020, she has been working as Brand Strategist in a brand consulting and management company, Brand Partner Indonesia.

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