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Korea Container Ports and Spatial Effects on Manufacturing

by

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Declaration of Authorship

I, Yong An Park, declare that this thesis titled, ' Korea Container Ports and Spatial Effects on Manufacturing ' and the work presented in it are my own. I confirm that:

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- ■ Where I have consulted the published work of others, this is always clearly attributed.
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Abstract

Over the last half century, the Korean economy has progressed its status from that of an underdeveloped country to a developed and dynamic economy, now home to global brands working in shipbuilding and the automobile, electronics, and mobile phones, amongst others. Crucial to this rapid progress, shipping and ports have functioned as a lifeline by moving almost 100% of exports and imports. Examination of the effects of Korean container ports on the manufacturing industries is important to enhance our knowledge on the relationship between a port and its region.

By looking at the regional panel datasets of all Korean manufacturing industries and port activities, the thesis first finds that the economic effects of Busan Port on the manufacturing industries in Korea are positive. The thesis notices that the regional effects of container ports vary in accordance with temporal changes and regions. In the case of the implementation of the container system in Korea we can look at two periods. The first period from 1991 to 1998 demonstrates positive coefficients of container throughput from Busan Port. However, the coefficients are inconclusive in the second period, 1999-2011. We find that the transshipment activity of Korean container ports does not affect overall the output of Korean manufacturing industries in the port cities and other regions.

By undertaking a case analysis of the leather, bag and shoe industry, and the automobile industry, we find differences in regional effects of container throughput of ports by period and by region. Following these findings, the thesis defines a new classification of container port on the basis of shipping and inland transport networks, and suggests hub indexes by combining differently two sub-indexes of port classification and container handling capacity of container ports.

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- Park, Y.A. and Medda, F. (2018). Spatial effects of container ports on production of the leather, bag, and shoe Industry in Korea. *International Journal of Shipping and Transport Logistics*, 10(1), 1-17.

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Abbreviations

CY	**C**ontainer **Y**ard
DMZ	**Dem**ilitarized **Z**one
EA	**E**ast **A**sia
Fisher- ADF	**Fisher**-type unit-root test based on **A**ugmented **D**ickey-**F**uller tests
FTA	**F**ree **T**rade **A**greement
FTZ	**F**ree **T**rade **Z**one
GDP	**G**ross **D**omestic **P**roduct
GLS	**G**eneralized **L**east **S**quares
G/T	**G**ross **T**onnage
HHI	**H**erfindahl **H**irschman **I**ndex
ICD	**I**nland **C**learance **D**epot
	or **I**nland **C**ontainer **D**epot
IMF	**I**nternational **M**onetary **F**und
IS	**I**nland transport network **S**cale
KITA	**K**orea **I**nternational **T**rade **A**ssociation
LLC	**L**evin-**L**in-**C**hu unit-root test
MOF	**M**inistry of **O**ceans and **F**isheries of Korea
NA	**N**orthern **A**merica
NE	**N**orthern **E**urope
PCI	Sub **i**ndex of **P**ort **Cl**assification

PSI	**S**ub **i**ndex of **P**ort capacity
RCA	**R**evealed **C**omparative **A**dvantage
RGDP	**R**egional **G**ross **D**omestic **P**roduct
RO/RO	**R**oll **O**n-**R**oll **O**ff
SA	**S**outhern **A**merica
SDM	**S**patial **D**urbin **M**odel
SE	**S**outhern **E**urope
SKD	**S**emi-**K**nock**d**own
SMA	**S**eoul **M**etropolitan **A**rea
SS	**S**hipping network **S**cale
TEU	**T**wenty-foot **E**quivalent **U**nit
TOC	**T**erminal **O**perating **C**ompany
T/S	**T**rans**s**hipment
TSI	**T**rade **S**pecialization **I**ndex
UK	**U**nited **K**ingdom
UNCTAD	**U**nited **N**ations **C**onference on **T**rade **a**nd **D**evelopment
WB	**W**orld **B**ank
WTO	**W**orld **T**rade **O**rganization

1. Introduction

1.1 Background

Despite the fact that the global economy has endured several market upheavals over the last half century, the Global Financial Crisis of 2008 nevertheless severely impacted on the shipping market, decreasing cargo movement by 3.6% in 2009 (Clarkson Research Services, 2011). While the total cargo tonnage of shipping worldwide fell slightly from 8.58 billion tonnes (bt) in 2008 to 8.27 bt in 2009, the tonnage of container cargoes has demonstrated even higher vulnerability, decreasing by 11.0% from 1.27 bt in 2008 to 1.13 bt in 2009 (Clarkson Research Services, 2016). Demand did recover after 2009, but the competition between global shipping liners in companies such as Maersk has since intensified due to long-term overcapacity from 2009 onward (Drewry Shipping Consultants Ltd., 2015).

The largest impact of the 2008 crisis on the Korean maritime industry was most evident in the container-shipping sector, and has affected two major shipping companies in particular: Hanjin Shipping ranked 13th among world liners, and Hyundai Merchant Marine ranked 17th in 2016 (Clarkson Research Services, 2016). Furthermore, the bankruptcy of Hanjin Shipping in 2017 shed light on the vulnerability of the Korean maritime sector (Dulebenets, 2018). In early 2016, Korea recorded a world ranking of 5th in the controlled merchant fleet, as shown in Table 1.1, which included Korean flag vessels and vessels controlled by Korean shipping companies.

Table 1.1: World rank of total merchant fleet in 2016

Rank	Country	Year	Number of ships	1,000DWT
1	Greece	2015	4,252	308,128
		2016	4,439	324,406
2	Japan	2015	4,135	215,540
		2016	4,187	229,942
3	China, PR of	2015	4,720	149,210
		2016	4,770	160,905
4	Germany	2015	3,645	123,574
		2016	3,456	120,793
5	Korea, Rep. of	2015	1,623	85,167
		2016	1,635	81,977

Source: Institute of Shipping Economics and Logistics (2016).

The lagging behind characterised by container shipping in Korea reveals the vulnerable position of its ports, especially the container ports and terminals that mainly handle transshipment containers. The throughput of transshipment containers in Busan Port, for example, fell from 10,105 thousand twenty-foot equivalent unit (TEU) in 2015 to 9,835 thousand TEU in 2016, indicating a slight drop in throughput of total containers from 19,469 thousand TEU to 19,456 thousand TEU during the same period (Ministry of Oceans and Fisheries of Korea, 2017). This decrease of transshipment containers was caused largely by the results of the downfall of Hanjin Shipping in 2016, which had contributed 14% of container throughput of Busan Port (Journal of Commerce, 2016). Meanwhile, Incheon Port as a gateway port of Seoul, the capital city of Korea, showed a growth of 10% from 1,835 thousand TEU in 2015 to 2,020 thousand TEU in 2016. Nevertheless, the Korean government has projected that Busan Port will receive a ranking of world number two in the container transshipment by 2020 (Ministry of Oceans and Fisheries of Korea, 2016). Busan, a hub port in Korea and North-East Asia mainly handles container cargo, comprised 92.6% of total cargoes in year 2015: 333 million tonnes (mt) of 360 mt (Ministry of Oceans and Fisheries of Korea, 2017). Put another way, the ratio of transshipment cargo of Busan Port measured in tonnes was approximately 60% of total tonnage in 2015 (Ministry of Oceans and Fisheries of Korea, 2017).

Since transshipment requires little connection with port hinterlands, we question whether the specialization development strategy for Busan Port to grow as a global transshipment hub is appropriate for enhancing the regional and national economic effects of the port. What is the best strategy for providing flexibility against vulnerability in the maritime sector?

Contrary to the planning of Busan Port, Rotterdam's plan emphasizes flexibility in its vision for 2030 through its industrial and logistics activity by setting targets to become both a global hub and Europe's industrial cluster (Port of Rotterdam, 2017). Rotterdam Port underwent evaluation to focus its activity on the role of gateway into Europe (Van Klink and Van den Berg, 1998). Rather than to focus solely on shipping connections for attracting transshipment, the vision outlines plans for diverse hub functions in inland transport, logistics chains, information exchanges, and even ecological aspects.

1.2 Objectives: basic questions

The movement and volume of a cargo entering and leaving a port is affected by the trade flow of its regional hinterlands. A deeper understanding of ports and affected regional economics is necessary for effective future planning of maritime trade and regional industries. The present thesis intends to trace the role of the container port when a manufacturing industry in a regional economy is exposed to global competition. The main objective of the thesis is to find the different regional economic effects of container ports in Korea on manufacturing industries. In so doing, the thesis evaluates the regional economic effects of container ports on the leather, bag and shoe manufacturing sector. Secondly, the thesis analyses the relationship between container ports and the automobile manufacturing industry, a main driver of the Korean economy, but an industry situated in dispersed regions, including Gyeonggi, Gwangju and Ulsan. The third objective of the thesis is to synthesise the analyses by proposing a port hub index, which indicates the status of container ports in both global shipping and inland transport networks.

Given the above discussion, this thesis focuses on the Korean maritime industry and its container terminals and ports of Busan, Incheon, Gwangyang, and Pyeongtaek. While limiting the analysis of the regional effects of container ports to the relationship between a container port and Korean manufacturing industries, we face several questions to which we can apply an analysis of regional datasets. The objectives are managed in the thesis through several questions.

Major question: Do container ports in Korea affect the regional economies with a particular focus on manufacturing industries?

Container cargo has been the backbone of dry cargo for Korea, even when we exclude the dry bulk cargoes of iron ore, coal and grain. Fluctuation in container movement is what most affects the fortune of ports that aim to attract general dry cargoes. For example, the tonnage of total dry cargo in the world was around 7,218 mt in 2015, composed of 4,687 mt of dry bulk cargo, 1,686 mt of container cargo, and 845 mt of other dry cargo (Clarkson Research Services, 2016). Container shipping transports 52% of trade cargoes by value in the world (Lloyd's Marine Intelligence Unit, 2009; Lee and Song, 2017).

The main container cargo in Korea consists of manufactured goods. In 2015 for example, as shown in Figure 1.1, manufactured goods represented 81.0% of total cargo in Korean ports, with about 82.0% through Busan Port. When compared against the volume of goods of agricultural and fishery: 16.0 %, and mineral products: 3% (Korea Customs Service and Korea Trade Statistics Promotion Institute, 2016), this high percentage indicates the importance of evaluating the effects of container ports in relation to manufacturing.

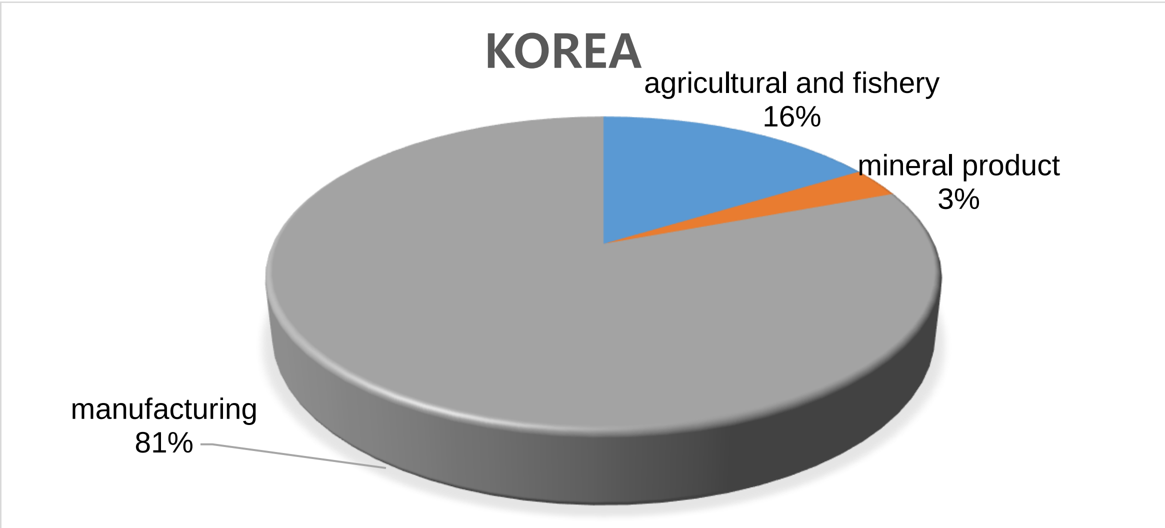

Figure 1.1: Container cargoes by commodity types of Korean ports in 2015.
Source: Author's elaboration of the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

Port development results in better shipping services and improved accessibility to global markets from the view of each establishment and manufacturing industry (Goss, 1990). In addition, Park and Seo (2016) find overall positive impact of ports on regional economies in Korea. On the one hand, a manufacturer may improve its productivity and competitiveness due to the more frequent liner services and lowered shipping costs, and can import more processed materials and parts from foreign countries. On the other hand, a manufacturer can meet a strong foreign competitor who may enjoy lower transport costs in selling their goods. In addition, the global competitiveness of a manufacturing industry depends on the degree to which its nearest port is developed.

Furthermore, the answer to our main question can be addressed after controlling other factors, which might affect the competitiveness of each manufacturing establishment: other transport infrastructures such as road and railway; global competitiveness of Korean manufacturing industries; and other regional and seasonal factors. When we limit the analysis to evaluating the effects of container ports on the area of production, we are able to collect data of output and input of each manufacturing establishment and adopt the production function of microeconomics with controlled variables.

From the main questions, we can address several sub-questions so that we may further investigate the role of container ports in relation to regional economies.

- *Does a container port affect Korean manufacturing industries differently?*
- *Do the effects of a container port on Korean manufacturing industries vary by manufacturing industry, by period and by region?*
- *Does a container port enhance the productivity of other inputs?*
- *Does transshipment activity affect Korean manufacturing industries?*
- *Is there a classification or an index of container ports that signals the regional effects of a container port?*

The first sub-question is explored in **Chapter 4** by examining the effects of container ports on aggregated activities of all manufacturing industries. The analysis of the effects of container ports is done differently by region and by period. While testing the effects of container ports on our two representative industries: the leather, bag and shoe industry in **Chapter 5** and the automobile industry in **Chapter 6**, the thesis examines **the second sub-question**. Since the leather, bag and shoe industry is labour-intensive, the thesis chooses the industry as representing the effects of port development on labour-intensive industries in Korea from 1991 to 2011. Korean manufacturing industries have global brand acknowledgement in shipbuilding, automobile, electronic goods such as mobile phones, and others. The export volume of electronic goods including mobile phones comprised 36.0% of total air transport cargo in Korea in 2015 (Korea Customs Service and Korea Trade Statistics Promotion Institute, 2016). The export of shipbuilding is indicated in the transport of the ships themselves. For this reason, the automobile industry is the logical choice as a user of container ports among the manufacturing industries of global brands in Korea. The examination of the effects of container ports on the automobile industry will shed light on the interaction between a port and a leading industry in the Korean economy.

The third sub-question examines the moderating effects between port activity and productivity of other inputs. Some of the maritime industry literature explores the moderating effects in order to examine the influence of factors on the relationship between different variables (Blas and Carvajal-Trujillo, 2014; Cho and Kim, 2015). If port activity affects the relationship between the output of Korean manufacturing industries and the inputs of production, we will find a moderating effect. If a port, as a public capital, plays only the role of regional infrastructure that lowers transport costs, port development may not clearly reveal the moderating effects on other production inputs such as labour, capital and intermediates. Nevertheless, transport systems including ports might broaden and integrate their networks of production and procurement in manufacturing industries such as automobile manufacturing (Diaz-Madronero et al., 2017). Here, the thesis explores the question of whether the development of Korean container ports brings a positive moderating effect or not in **Chapters of 4, 5 and 6**.

The fourth sub-question is quite important in assessing the transshipment activity of a container port. Nowadays, a hub port tends to handle a significant ratio of transshipment containers (Drewry Maritime Research, 2017). This question will clarify the economic relationship between a hub port and its region. The fourth sub-question is also explored in **Chapters of 4, 5 and 6**. Thereafter in **Chapter 7**, we use the findings on the relationship between transshipment of a container port and regional manufacturing in order to develop a classification of container ports.

The fifth sub-question proposes a new classification in **Chapter 7** through which we can evaluate the effects of container ports on a regional economy, in particular, on the manufacturing industry. Next, the thesis develops and tests different types of port hub index in **Chapter 8**.

These sub-questions will provide us with specific findings on the regional role of container ports in Korea. The analysis of the transshipment activity of a hub port in Korea sets out to inform future projections of the relationship between a container port and its region.

Korea is a good candidate for exploring these focused questions on the effects of container port development on a regional economy because the country has shown dynamic changes in its economy and maritime industries since the 1960s. The continual growth of an export-driven economy has precipitated the massive expansion of foreign trade and the excess service demand in maritime industries up until the late 1990s (Cullinane and Song, 1998). In the process of economic development, Korean shipping and port industries have played a key role in the national economy by handling 99.6% of exports and imports (Ministry of Land, Transport and Maritime Affairs of Korea, 2009a). The maritime industry leapt into the role of leading player from its previous lower status in the global market. For example, as mentioned above, Busan Port soared to the world’s

Top 5 container port in the 1990s after having been 24th in the 1976 ranking; it began attracting transshipment containers from China and Japan (Chang, 2000).

In some cases, a port city in Korea embraces a leading manufacturing industry. The manufacturing of leather goods, bags and shoes in Busan, a hub port city in Korea (Figure 1.2), shared about 22% of total output of regional manufacturing industries in 1991. Yet the share of industry held by leather goods, bags and shoes in Busan has decreased steadily throughout the 1990s and 2000s. The analysis of effects on regionally specialized manufacturing industries, such as the leather, bag and shoe industry in Busan, in accordance with the development of a container port in Korea will help us to better understand the economic relationship between a port and its hinterlands.

Figure 1.2: Location of Korea and main container ports in Korea and Asia.
Source: Author's elaboration of the map by Arcgis (2011).

1.3 Thesis contribution

The thesis reviews the regional effects of container ports on each establishment of manufacturing industries in Korea that depends on the import of parts and components, and the export of goods through container ports. Using a panel dataset of each business unit allows us to analyse the effects of container ports on our selected manufacturing industries. Moreover, while controlling for the changes of global comparative competitiveness of the specific manufacturing industry and other transport infrastructure such as road, the thesis tries to examine precisely the effects of port development on each manufacturing sector.

Secondly, this thesis finds the different relationships between container ports and manufacturing industries through the examination of the effects of container ports by region and by period. The spatial and temporal analysis of the effects of container ports on manufacturing industries enables us to understand the diverse effects of container ports and the interaction between a port and its region. Furthermore, a microeconomic investigation of longitudinal and cross-sectional cases provides a hint about the phenomena of specialization and international division of manufacturing production.

Thirdly, the thesis establishes a new classification of container ports that aims at evaluating the status of container ports in a shipping network and categorizing the logistics services of container ports for shippers. The new classification of container ports includes the characteristics of both shipping networks and inland transport networks. By considering both shipping and inland transport networks, the new classification can harness the assessment tool of the regional role of container ports and help us to acknowledge the diverse roles of container ports in intermodal transport and their relationship with regional economies.

Fourthly, the thesis suggests a port hub index to indicate the status of container ports in both global shipping and inland transport networks. The index has been developed to complement existing indexes for container ports, e.g., the Liner Shipping Connectivity Index, the port accessibility index of world shipping networks, and the assessment index of hub status (UNCTAD, 2005; Cullinane and Wang, 2009; Low et al., 2009). The abovementioned indexes have been calculated mainly by assessment of shipping connections and are difficult and complicated to use on a global scale. Whereas, the suggested port hub index is more user-friendly and allows the user to calculate easily.

1.4 Thesis structure

The thesis follows the structure outlined below (Figure 1.3).

Chapter 2 will address the growth of the Korean maritime industry and the main drivers of its growth. The export-driven Korean economy has helped the Korean maritime industry to develop from a minor to a major global player. After discussing the context of the Korean maritime industry, the Chapter reviews the structural changes in production for the main regions of the 16 administrative regions in Korea (Figure 1.4).

Chapter 3 gives a background of data used in the thesis and describes the microeconomic approach of the production function of each establishment within the manufacturing industries. The Chapter also explains the use of a panel data model that has been adopted as the main tool for exploring the panel data of Korean manufacturing industries. Chapters of 4, 5 and 6 examine the differences of effects of container ports by period and by region. The Chapters also investigate the effects of transshipment activity on manufacturing industries in Korea.

While considering the development of the Korean economy and Korean maritime industries, **Chapter 4** examines the regional effects of Korean container ports on the manufacturing industries. **Chapter 4** handles the panel data of enduring establishments from 1991 to 2011, and arranges each of the enduring establishments into 16 regional groups in accordance with 16 administrative regions in Korea (see Figure 1.4).

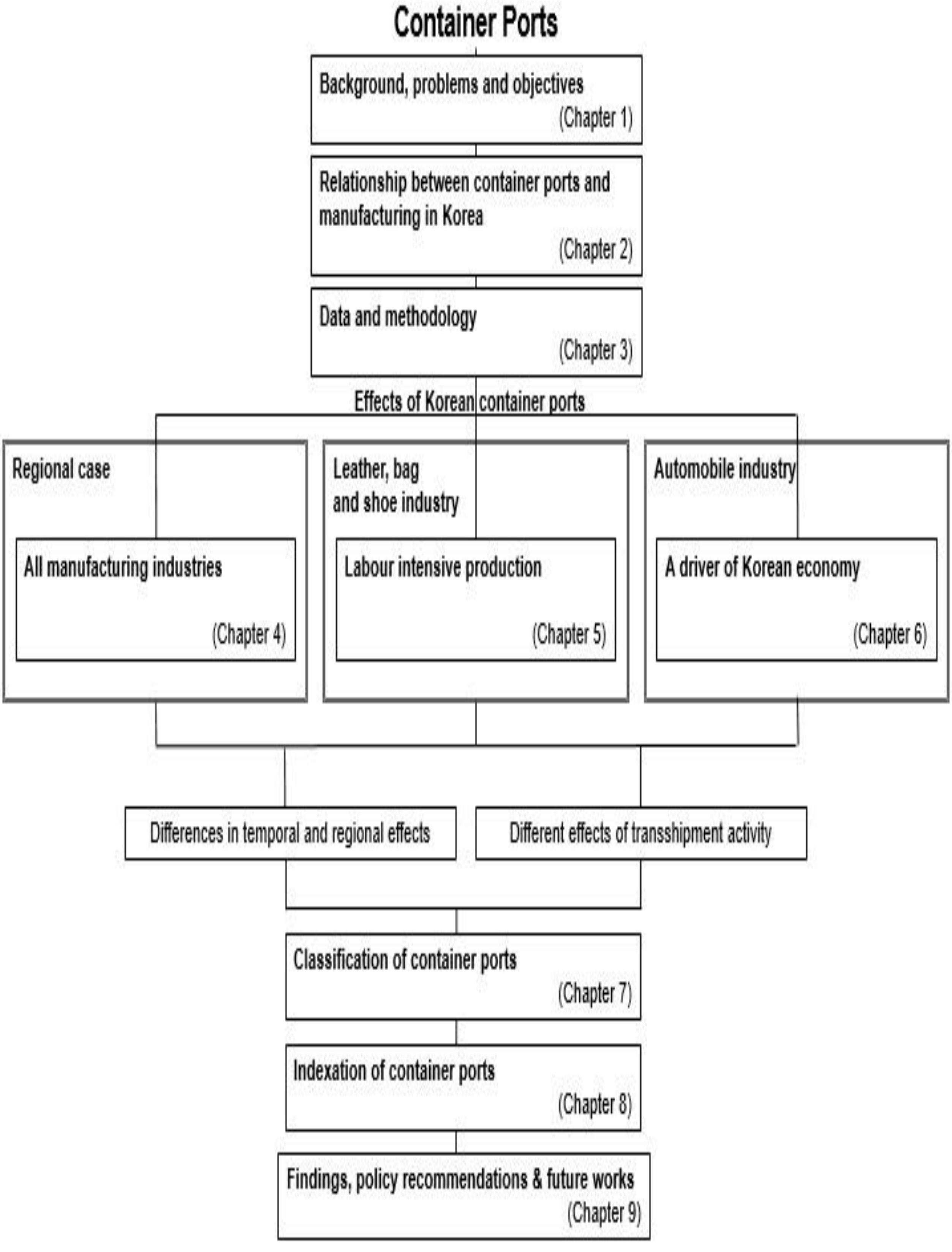

Figure 1.3: Thesis structure

Figure 1.4: Sixteen Administrative regions
Source: Author's elaboration of the map at Jidomall (2015).

After studying the regional effects of Korean container ports on the manufacturing industries, we analyse the spatial effects of Korean container ports on the leather, bag and shoe industry in **Chapter 5** by testing whether regional effects of port development are positive, negative or neutral. In the thesis, we test the general assertion that development of a container port in a region has a positive effect on that region. The thesis uses the regional panel datasets of the leather, bag and shoe industries in 16 regions from 1991 to 2011, and port activity variables including container throughput. Similar to Chapter 5**,** in **Chapter 6** we look at the spatial effects of Korean container ports on the automobile industry in order to demonstrate the different manufacturing characteristics from the leather, bag and shoe industry.

New findings from Chapters of 4, 5 and 6 will give us insights into the relationship of container ports and both regional and national economy. The functional separation between shipping and inland transport networks is possible to examine by reviewing the regional effects of the transshipment activity of Korean ports in Chapters of 4, 5 and 6. **Chapter 7** categorizes container ports in accordance with the hierarchical status of a container port within the shipping and inland transport networks. This categorization will be informed by reviewing the development of global intermodal networks of container shipping and progress in inland transport networks. The new hierarchical classification suggested in Chapter 7 defines nine types of container ports in relation to three shipping networks and three inland transport networks, and is intended to indicate the hub status of a container port.

The Chapters focusing on our Korean cases provoke the necessity for a new hub index in shipping in order to clarify the relationship between container ports and regional economies. **Chapter 8** develops a hub status indexation of container ports. The study develops two sub-indexes of port classification and capacity, and combines cases from these two sub-indexes into various types in order to find a proper port hub index. The findings demonstrate how different types of port hub index are useful measurements in the evaluation of outputs and inputs of container ports. **Chapter 9** summarises the results of the thesis, highlights the most important conclusions, and suggests possible policy implications to shareholders and stakeholders in the maritime industry.

2. Context

2.1 The Korean economy and maritime industries

2.1.1 Export oriented economy and maritime industry

During the last half-century, the Korean economy and maritime industries have demonstrated a dynamic change in their growth and status in the world. Korea has progressed itself economically from a developing country to a developed country with many global brands in manufacturing. Within the global maritime network, Busan Port, as a representative of Korean container ports, ranks sixth in the world, handling about 19.5 million TEU in 2015 (Ministry of Oceans and Fisheries of Korea (MOF), 2017; Busan Port Authority, 2017).

The Korean economy has recorded continuous growth since the 1960s, enduring even after a few short recessions such as the 1997 economic crisis. With the increase of population from 25.4 million in 1961 to 43.3 million in 1991 and to 50.3 million in 2015 as shown in Table 2.1, GDP has soared from 291 billion Korean won to 216.5 trillion Korean won and to 1,558.6 trillion Korean won during the same period (International Monetary Fund(IMF), 2017). The course of Korean economic growth can be paralleled with the continual increase of trade: exports increasing from 41 million US dollars to 70.5 billion US dollars and to 548.8 billion US dollars during the same period; and imports from 283 million US dollars to 77.3 billion US dollars and to 428.5 billion US dollars (IMF, 2017).

In accordance with the development of the Korean economy driven by export oriented economic policies, total cargo movement of exports and imports at Korean ports increased from 28.4 million ton in 1971 to 172.9 million ton in 1991 and to 1.2 billion ton in 2015 as demonstrated in Table 2.2 (MOF, 2017). The Korean flag ocean-going merchant fleet expanded from 7.3 million gross tonnage (G/T) in 1981 to 12.2 million G/T in 2001 and to 42.3 million G/T in 2015; the registered merchant fleet from 4.9 million G/T in 1981 to 6.6 million G/T in 2001 and to 13.4 million G/T in 2015 (MOF, 2017).

Table 2.1: Main indicators of Korean economy

Item/year	1961	1971	1981	1991	2001	2011	2015
Population (million)	25.4	32.9	38.7	43.3	47.0	48.7	50.3
GDP (billion of Korean won)	291	3,379	47,383	216,511	622,123	1,332,681	1,558,592
GDP per capita, Korea (US$)	93.8	300.7	1,870.3	7,523.5	12,252.9	24,079.8	27,538.8
GDP per capita, World (US$)	462.3	868.1	2,537.3	4,450.8	5,378.8	10,443.9	10,150.8
Exports of goods (million of US$)	41	1,133	20,747	70,541	151,478	587,099.7	548,837.8
Imports of goods (million of US$)	283	2,177	24,596	77,344	137,990	558,009.8	428,547.8

Source: IMF (1991, 2003, 2006, 2016) and World Bank (2017).

Table 2.2: Main indicators of Korean maritime industry

Item/Year		1971	1981	1991	2001	2011	2015
Total Cargo (Thousand ton)	Export	4,191	26,297	35,503	177,565	365,812	419,311
	Import	24,257	79,023	137,432	433,345	703,753	799,469
Container throughput (Thousand TEU)	Export	n.a.	465	1,432	3,285	6,658	7,456
	Import	n.a.	409	1,135	3,306	6,755	7,506
	T/S	n.a.	7	70	3,111	7,719	10,719
Ocean going merchant fleet (Thousand G/T)		n.a.	7,302	8,905	12,184	32,186	42,300
Shipbuilding (Thousand G/T)		n.a.	1,229	5,434	10,832	21,047	22,102
Registered merchant fleet (Thousand G/T)		889	4,896	7,274	6,593	13,671	13,392

Note: n. a.: not available.

Source: Author's elaboration on the data of Statistics Korea (2017) and MOF (2017), and Korea Maritime Institute (2017)

On this course of economic and maritime power growth, the Korean government has led the development and construction of port facilities and the capacity of Korean flag vessels to handle increasing cargo movements since the 1960s (Jun and Kim, 1991; Cullinane and Song, 1998). At the initial stages of the industrialization of Korea in the 1960s, the Korean government built ports and industrial complexes in a near distance. Those ports help Korean exporters and importers to improve price competitiveness through reducing logistics costs of intermediates and parts from foreign countries, such as trucking costs, warehousing costs, and the indirect costs of unstable delivery time (Jun and Kim, 1991).

Containerisation of the shipping industry in the 1960s promoted the construction of container terminals in Korean ports. The container throughput of both exports and imports at Korean ports increased from 874 thousand TEU in 1981 to 2.6 million TEU in 1991 and to 15.0 million TEU in 2015 as shown in Table 2.2. Records of transshipment container throughput increased from 7 thousand TEU in 1982 to 70 thousand TEU in 1991 and to 10.7 million TEU in 2015 (MOF, 2017). In the 1990s Busan Port was able to develop its status in the global shipping network from a regional port to a hub port in the North-East Asia by attracting transshipment containers from Chinese ports and Japanese small ports through expanding feeder shipping routes (Chang, 2000; Yeo et al., 2008).

2.1.2 Development of Korean container ports

Korea has four main ports that between them handled 25.7 million TEU in 2015, about 96.4 % of the total container throughput in Korea. Busan Port handled 19.5 million TEU with 75.8 % of share; Incheon Port, 2.4 million TEU with 9.3 % of share; Gwangyang Port, 2.3 million TEU with 9.1 % share; and Pyeongtaek Port, 566 thousand TEU with 2.2 % of share (MOF, 2017). The introduction of container terminals at Busan Port and Incheon Port began in the 1970s, followed by Gwangyang Port opening its container terminal in 1998, and Pyeongtaek Port's participation in the container handling business beginning in the 2000s.

When referencing the Korean government strategy, the thesis uses the master development plan of major Korean ports proposed by the Korean government in 2011 and in 2016 (Ministry of Land, Transport and Maritime Affairs, 2011; MOF, 2016). Following the Port Act, the MOF has formulated the master plan for the major Korean ports such as Busan Port, Incheon Port, Gwangyang Port, and Pyeongtaek Port. Since the master development plans in 2011 and in 2016 are similar to each other in the area of development of the four major Korean container ports, the thesis refers to the master development plans in 2011. Busan Port was planned to become the world's second largest transshipment port by expanding its port facilities, which mainly handles transshipment containers. Incheon Port was designed as the gateway port of Seoul Metropolitan Area (SMA); Gwangyang Port as a multifunctional port with industrial complexes in near hinterlands; and Pyeongtaek Port as a regional gateway for handling raw materials, parts and components for the manufacturing industries mainly in SMA (Ministry of Land, Transport and Maritime Affairs, 2011).

Busan Port commenced its operation of container terminals in the 1970s as the gateway of Korea to the world while simultaneously serving as a feeder port in a branch-shipping network with Japanese hub ports, Kobe Port, Yokohama Port, Tokyo Port, and Nagoya Port (Park and Choi, 2013). In the initial years of container transport in the early 1970s, Busan Port had only one inland transport network: trucking. Busan Port started to build its feeder routes with Japanese regional ports in the late 1980s and expanded its feeder routes to Chinese regional ports in the 1990s (Park and Choi, 2012). However, Busan Port did face a new challenge in the late 1990s, experiencing severe competition in the catchment of transshipment containers of the neighbouring countries, in particular China (Yap et al., 2006; Anderson et al., 2008; Yeo et al., 2008). A decrease of transshipment containers in 2016 demonstrated the vulnerability of the transshipment activity of Busan

Port. The number of foreign ports directly connected with Busan Port by liners with a regular shipping schedule increased from 89 in 1981 to 364 in 2001 and to 421 in 2011 as shown in Table 2.3 (Korea Shipping Gazette, 1981, 2001, 2011).

Table 2.3: Number of foreign ports directly connected with Korean ports

Port/ Year	1971	1981	1991	2001	2011
Busan	119	89 (51)	165 (88)	364 (154)	421 (197)
Incheon	18	11 (2)	11 (2)	115 (26)	193 (70)
Gwangyang	-	-	-	187 (58)	213 (99)
Pyeongtaek	-	-	-	4 (0)	45 (11)

Note: The numbers in parenthesis indicate the number of foreign ports directly connected in intercontinental routes.
Source: Author's elaboration on the data of Korea Shipping Gazette (1971, 1981, 1991, 2001, 2011, 2017).

Incheon Port, which is located 28 km from Korea's capital Seoul, also has the geographical advantage of being in close proximity to the Chinese shipping network. However, its expansion has been hindered by developmental and legislative obstructions such as the Green Belt and the Seoul Metropolitan Area Readjustment Planning Act enacted in 1982, which is aimed to disperse the concentration of economic resources from SMA to other regions (Ministry of Government Legislation, 2015). Hence, Incheon Port handled containers mainly in Roll on-Roll off (RO/RO) terminals before it built exclusive container terminals in the 2000s. The number of foreign ports directly connected with Incheon Port by liners with a regular shipping schedule increased from 11 in 1981 to 115 in 2001 and to 193 in 2011 as shown in Table 2.3 (Korea Shipping Gazette, 1981, 2001, 2011).

While Busan Port and Incheon Port share a long history as major port cities, the container terminals of Gwangyang Port were planned to disperse the container throughput of Busan Port and handle transshipment containers from China in the late 1980s (Ministry of Land, Transport and Maritime Affairs, 2009b). Gwangyang Port has operated container terminals since 1998 (Yeosu Gwangyang Port Authority, 2017). Although Gwangyang Port should compete with existing ports such as Busan Port and Incheon Port by attracting containers from the hinterlands, it succeeded in building global shipping networks in the 2000s. The number of foreign ports directly connected with Gwangyang Port by liners with a regular shipping schedule increased from 187 in 2001 to 213 in 2011 as shown in Table 2.3 (Korea Shipping Gazette, 2001, 2011).

Pyeongtaek Port is located near SMA and has good accessibility to hundreds of industrial complexes and many of Korea's globally recognized electronic goods brands, such as Samsung Electronics and LG Electronics (Gyeonggi Pyeongtaek Port Corporation, 2015). It has been handling container ships since 2000. The number of foreign ports directly connected with Pyeongtaek Port by liners with a regular shipping schedule increased from 4 in 2001 to 45 in 2011 as shown in Table 2.3 (Korea Shipping Gazette, 2001, 2011).

2.2 Container ports and manufacturing industries

2.2.1 Korean container ports and hinterlands

The thesis uses the data of the containers domestic origin and destination of Korean export and import from the Korea Customs Service and Korea Trade Statistics Promotion Institute. The main hinterlands of Korean container ports are Seoul sharing 30.0 % of export and import containers in Korea in 2015 as shown in Figure 2.1, Gyeonggi with a 19.0 % share, and Gyeongnam with a 7.7% share (Korea Customs Service and Korea Trade Statistics Promotion Institute, 2016).

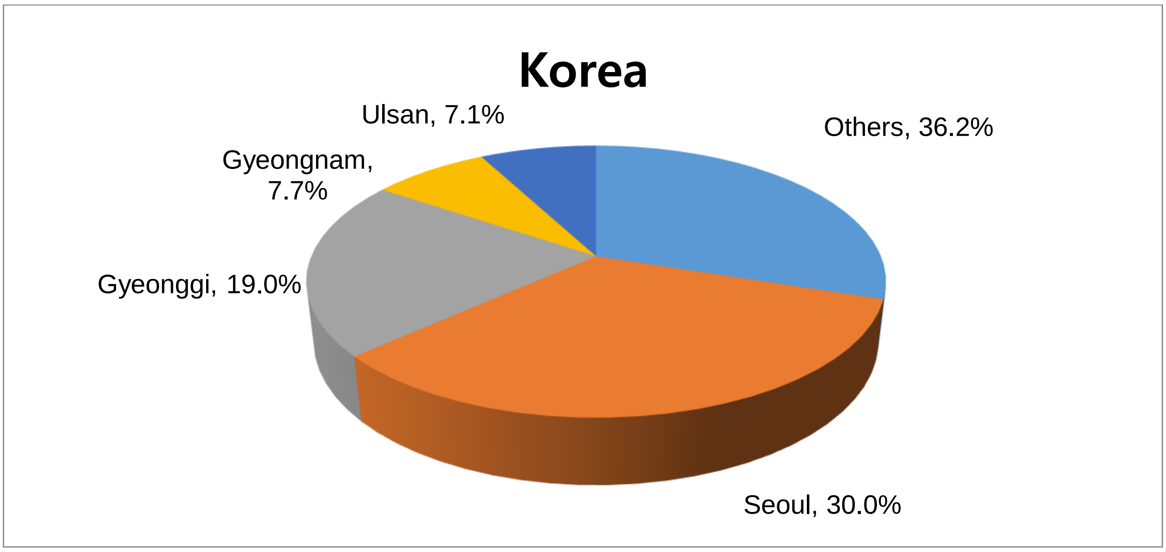

Figure 2.1: Main hinterlands of containers of Korean ports
Source: Author's elaboration on the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

Main import/export hinterlands of Busan Port are Seoul, with a 26.6% share of its total trade, Gyeonggi with a 16.9 % share, Gyeongnam with a 12.0 % share, Busan city with a share of 10.1 %, and other, smaller regions with a combined 34.4 % share in 2015 (Figure 2.2).

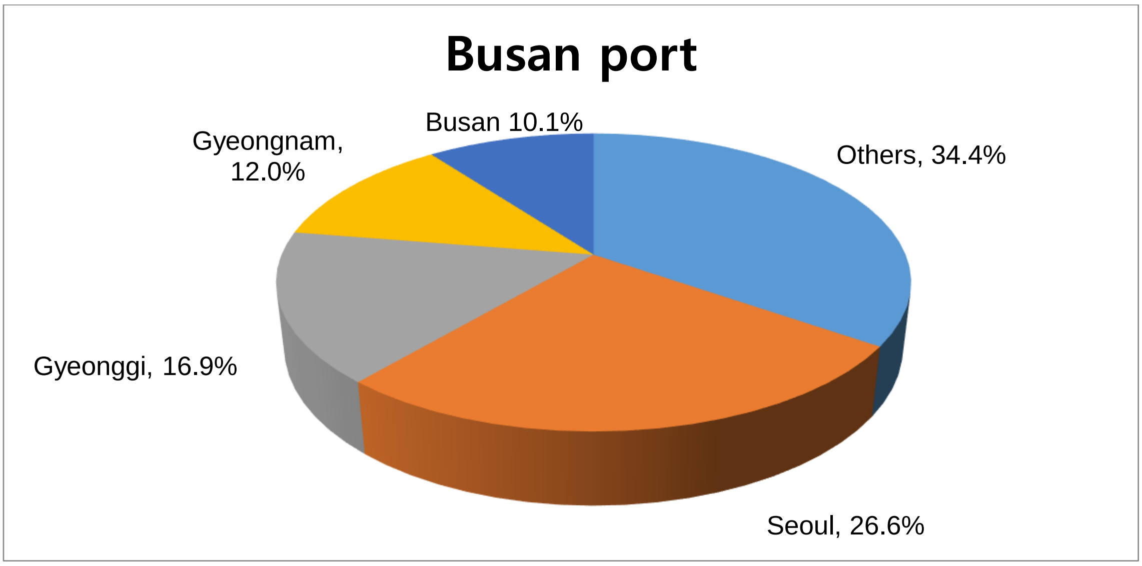

Figure 2.2: Main hinterlands of containers of Busan Port
Source: Author's elaboration on the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

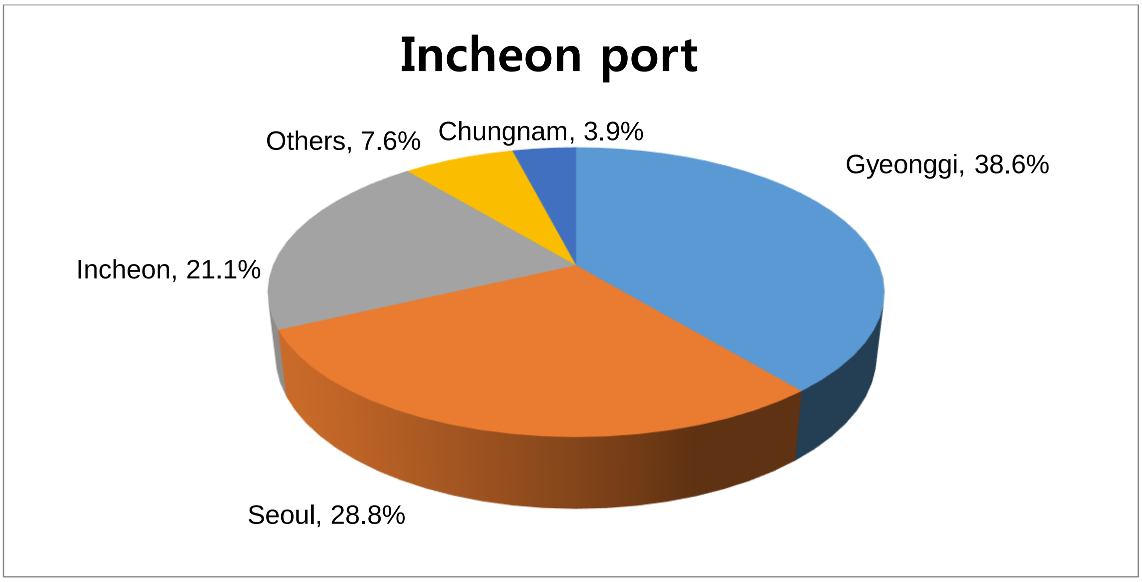

Figure 2.3: Main hinterlands of containers of Incheon Port
Source: Author's elaboration on the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

Incheon Port, Gwangyang Port and Pyeongtaek Port mainly deal with their local port city and neighbouring regions. Incheon Port's import/export hinterlands are mainly divided between Gyeonggi [38.6%], Seoul [28.8%] and Incheon City [21.1%] of containers in 2015 as shown in Figure 2.3; Gwangyang Port, Jeonnam [35.7%] and Gwangju [14.5%] as illustrated in Figure 2.4; and Pyeongtaek Port, Gyeonggi [39.0%] and Seoul [23.3%]

as illustrated in Figure 2.5 (Korea Customs Service and Korea Trade Statistics Promotion Institute, 2016).

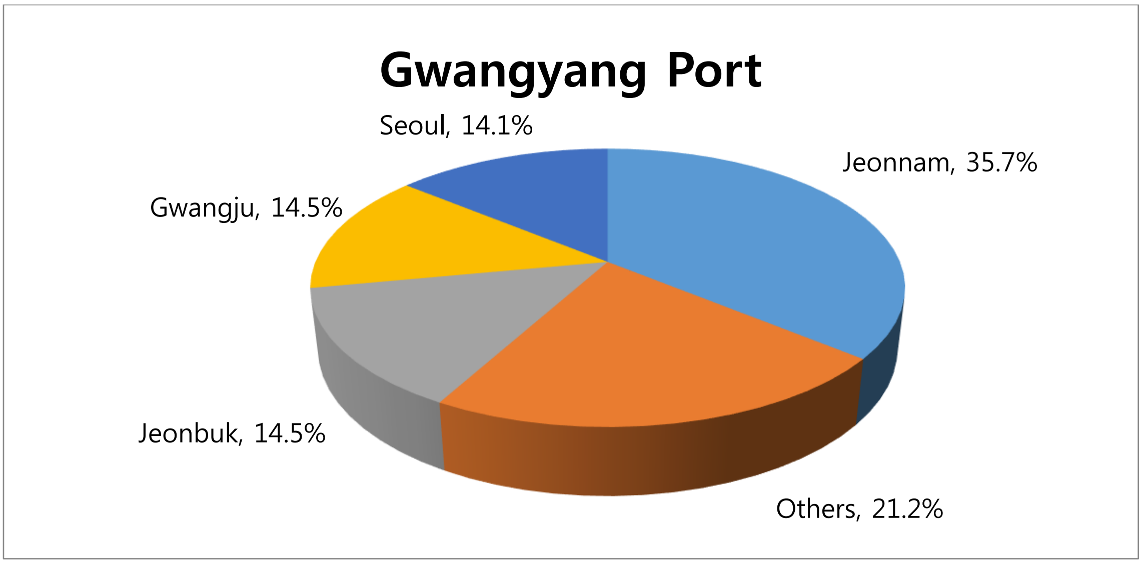

Figure 2.4: Main hinterlands of containers of Gwangyang Port
Source: Author's elaboration on the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

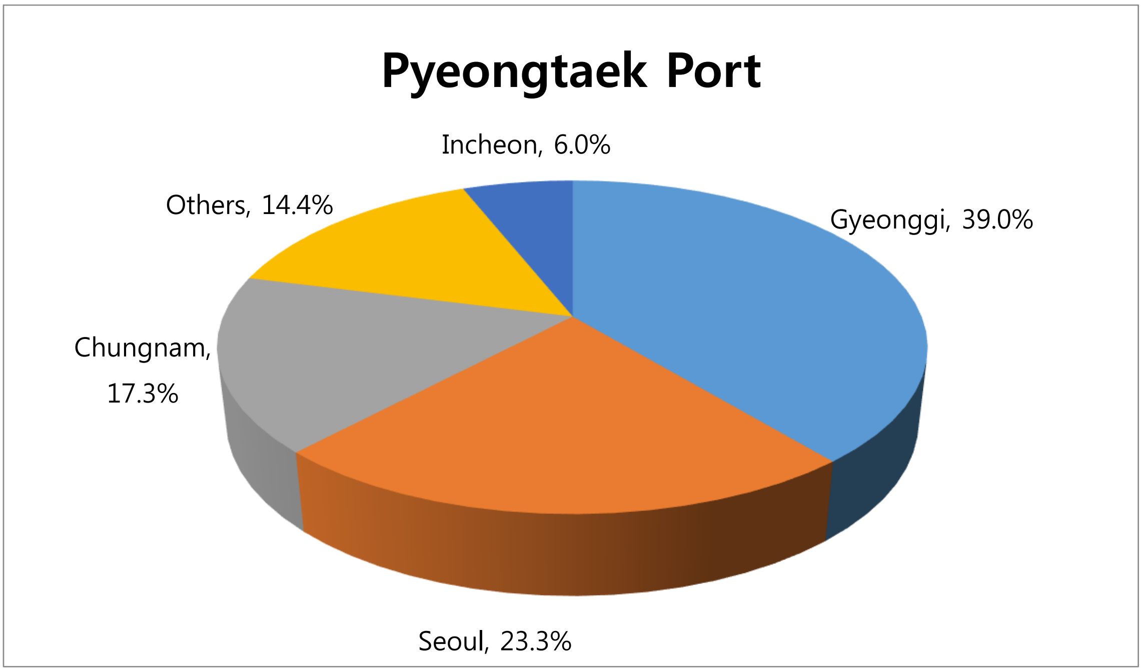

Figure 2.5: Main hinterlands of containers of Pyeongtaek Port
Source: Author's elaboration on the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

As we have seen in Chapter 1, the main type of cargoes inside containers at Korean ports is manufacturing good, sharing 81 % of all containers total tonnes. The ratio of manufacturing goods inside containers of Busan Port is 82 % as listed in Figure 2.6; Incheon Port 78 %, Gwangyang Port 80 %, and Pyeongtaek Port 72 %.

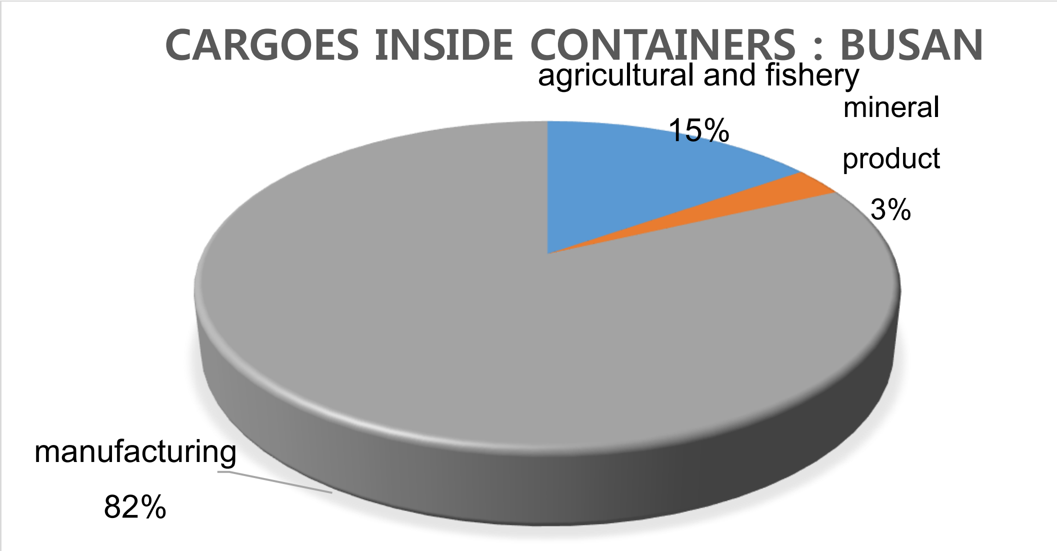

Figure 2.6: Ratios of cargoes inside containers of Busan Port

Source: Author's elaboration on the data of Korea Customs Service and Korea Trade Statistics Promotion Institute (2016).

2.2.2 Structural trends of regional manufacturing industries

The thesis observes the structural changes of regional production in Korea and identifies the main regions from 1991 to 2015 by calculating the ratio of each industry in 16 administrative regions in Korea. The thesis gathers the data of regional production issued by the Statistics Korea, Korean statistics office (Statistics Korea, 2017). In Korea, the ratio of manufacturing industries has increased from 24.2 % in 1991 to 24.6 % in 2001 and to 28.4% in 2015 as shown in Figure 2.7. On the contrary, the ratio of the transportation sector within Korea has decreased from 4.1 % in 1991 to 3.9 % in 2001 and to 3.2 % in 2015 (Statistics Korea, 2017, 2017).

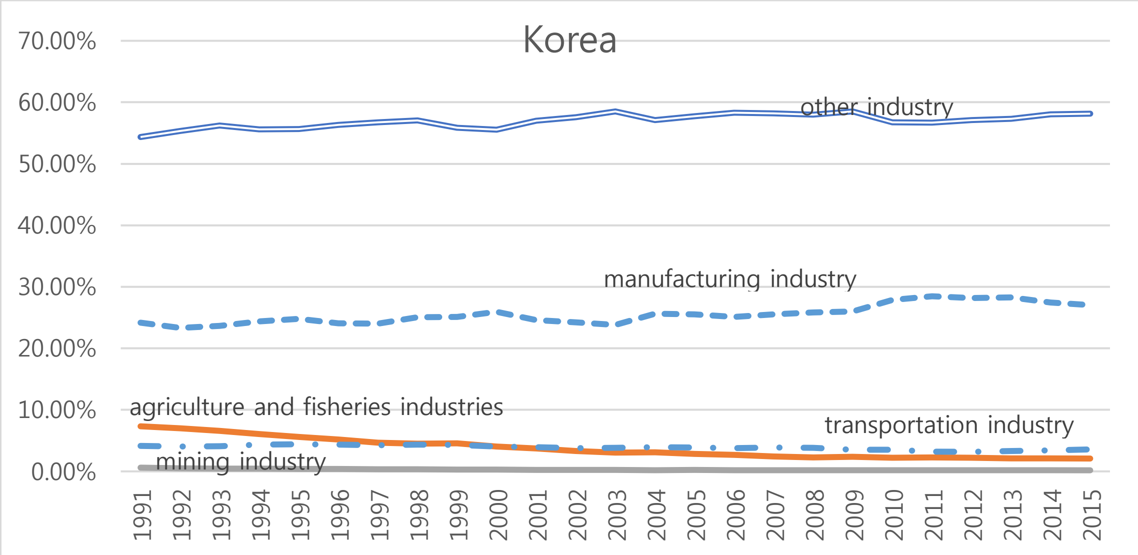

Figure 2.7: Ratios of each industry of Korean economy
Source: Author's elaboration on the data of Statistics Korea (2017).

The thesis reviews the change of industrial structure in Korea, first in a port city and then in its main hinterlands. In Busan, a port city, the ratio of manufacturing industries in regional production decreased from 27.1 % in 1991 to 17.6 % in 2001 and to 18.4 % in 2015, and the ratio of transportation increased first from 8.7% in 1991 to 10.5% in 2001 but fell to 6.5% in 2015 as shown in Figure 2.8. Although the container throughput of Busan Port shows an overall continual increase, the ratio of transportation in regional production has decreased in recent years. This appears to be caused by the ever-increasing rate of transshipment containers rather than a decline of containers of Korean exports and imports. While the throughput of transshipment containers at Busan Port increased from 6.3 million TEU in 2010 to 10.1 million TEU in 2015, recording 10.0 % of average annual growth rate, throughput of containers of Korean exports and imports rose slightly from 7.9 million TEU in 2010 to 9.4 million TEU in 2015, recording 3.4 % of average annual growth rate (MOF, 2017).

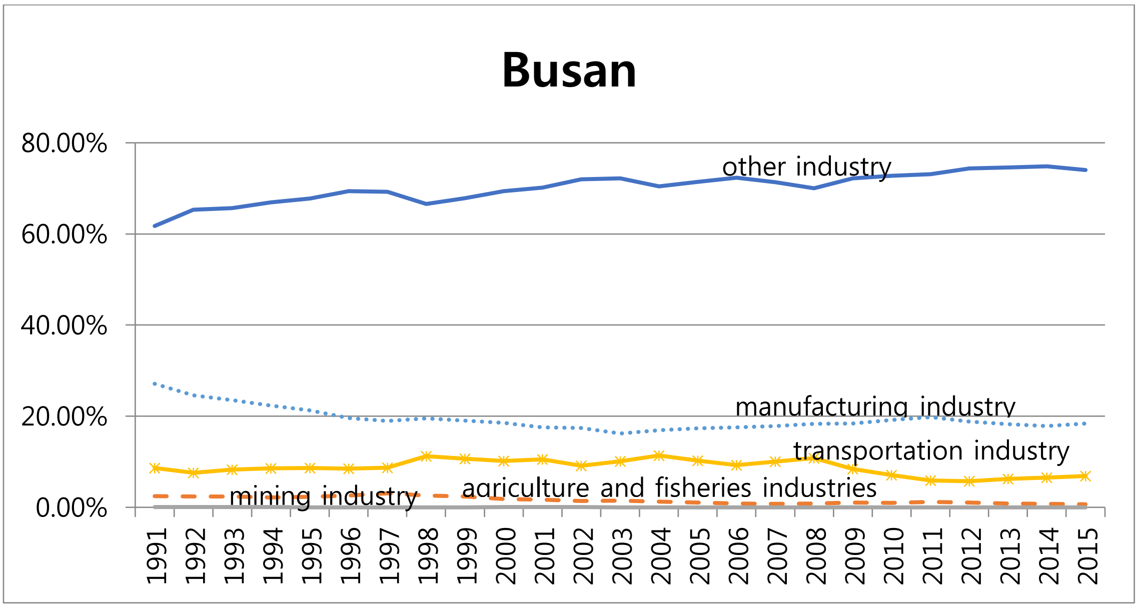

Figure 2.8: Ratios of each industry of Busan, Korea
Source: Author's elaboration on the data of Statistics Korea (2017).

In the port city of Incheon, the ratio of manufacturing decreased continually from 40.1 % in 1991 to 31.8 % in 2001 and to 25.7 % in 2015 (Figure 2.9). The ratio of transportation increased from 4.8% in 1991 to 8.1% in 2001 and to 10.3% in 2015. Incheon's increasing share of the transportation industry coincides with the timing of the opening of its new container terminals, the early 2000s. Since Incheon Port serves as a hub for SMA, rather than a transshipment hub in North-East Asia, derivative logistics demand such as surface transportation might grow in accordance with port development after 2000.

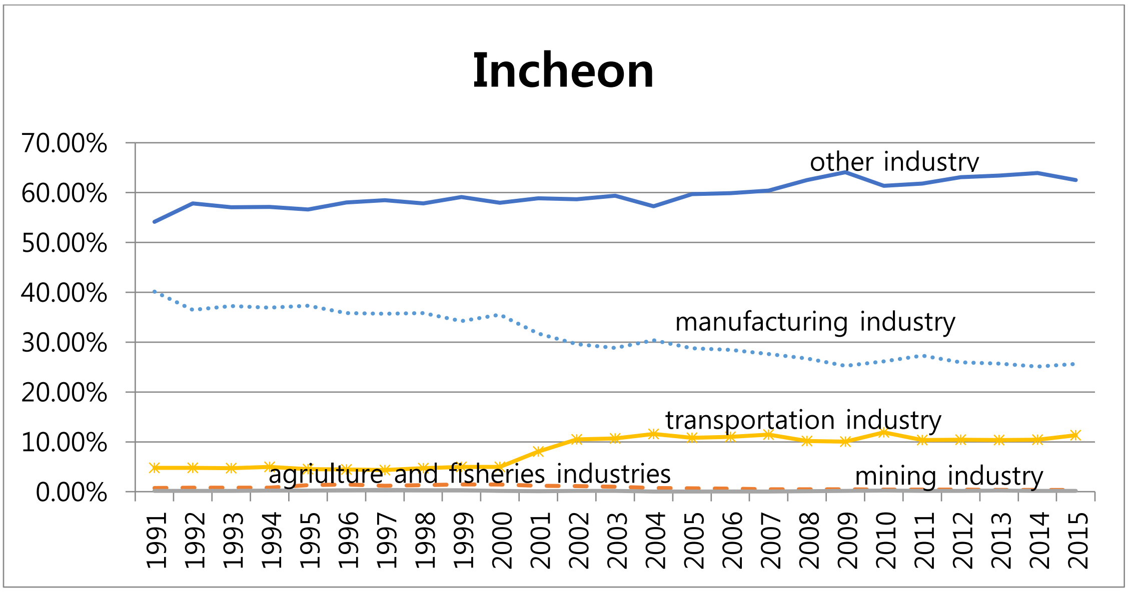

Figure 2.9: Ratios of each industry of Incheon, Korea

Source: Author's elaboration on the data of Statistics Korea (2017).

Jeonnam accommodates Gwangyang Port and is a main area of agriculture and fishery production. The region produced 970 thousand ton of the total 4,845 thousand ton of grain in Korea in 2015 as shown in Figure 2.10 (Statistics Korea, 2017). In Jeonnam the ratio of manufacturing increased overall from 20.7 % in 1991 to 23.6 % in 2001 and 29.3 % in 2015 (Figure 2.11). The ratio of transportation decreased from 5.1 % in 1991 to 4.4 % in 2001 and to 3.8% in 2015.

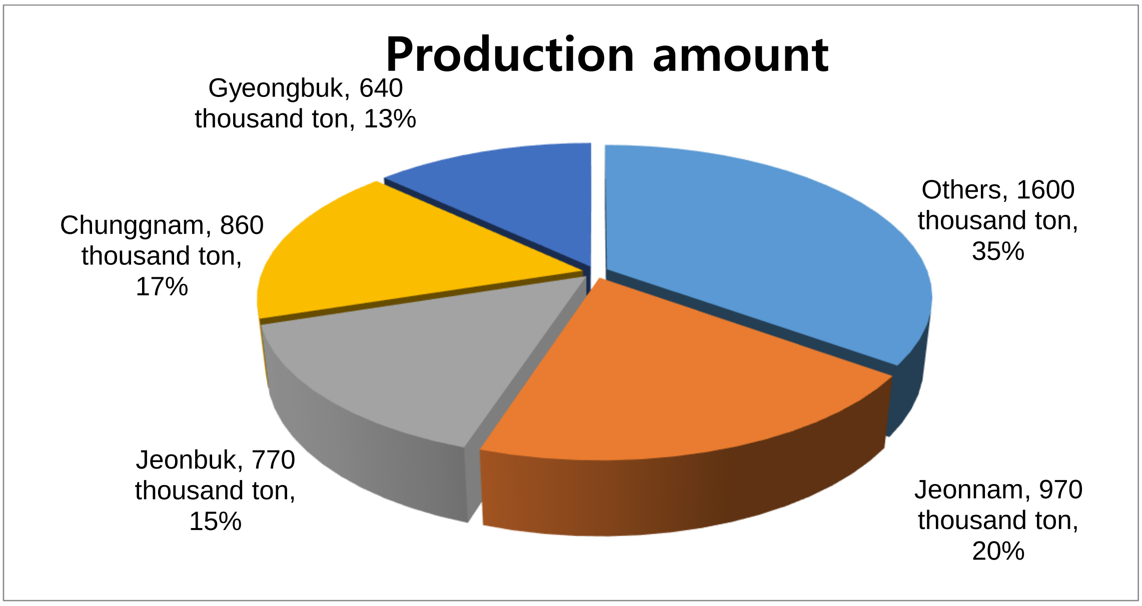

Figure 2.10: Grain production by region in 2015.

Source: Author's elaboration on the data of Statistics Korea (2017).

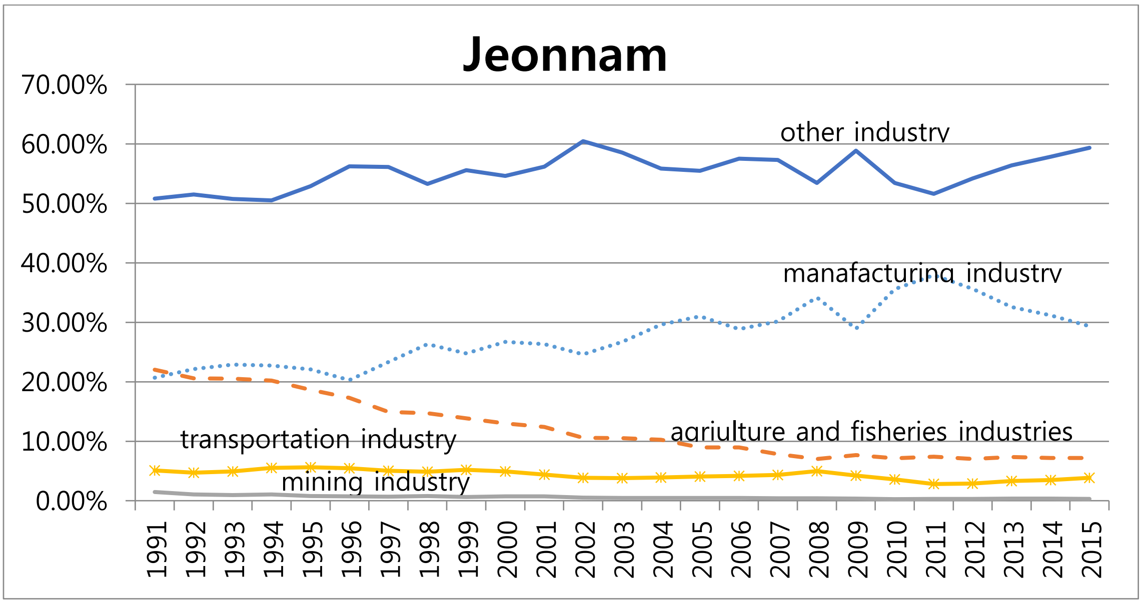

Figure 2.11: Ratios of each industry of Jeonnam, Korea

Source: Author's elaboration on the data of Statistics Korea (2017).

Gyeonggi houses Pyeongtaek Port for shippers and is a main area for industrial complexes including electronic manufacturing companies. Pyeongtaek Port started to handle container ships from the year of 2000. In Gyeonggi the ratio of manufacturing ranged from 30.7 % to 35.0 % during the period from 1991 to 2015 (Figure 2.12). Nevertheless, the ratio of transportation increased steadily from 1.7% in 1991 to 2.9% in 2011 and to 3.0 % in 2015.

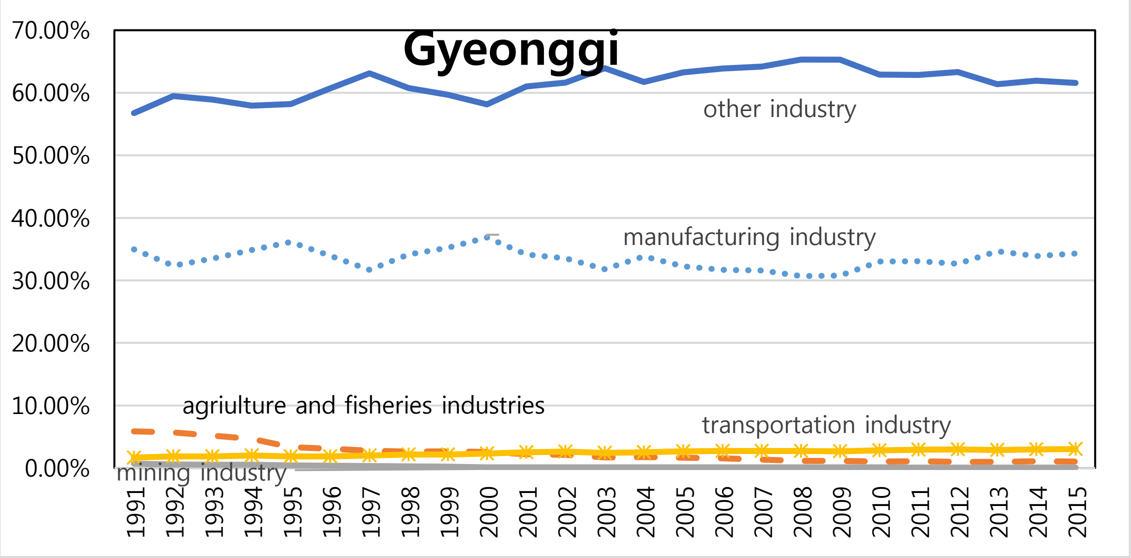

Figure 2.12: Ratios of each industry of Gyeonggi, Korea
Source: Author's elaboration on the data of Statistics Korea (2017).

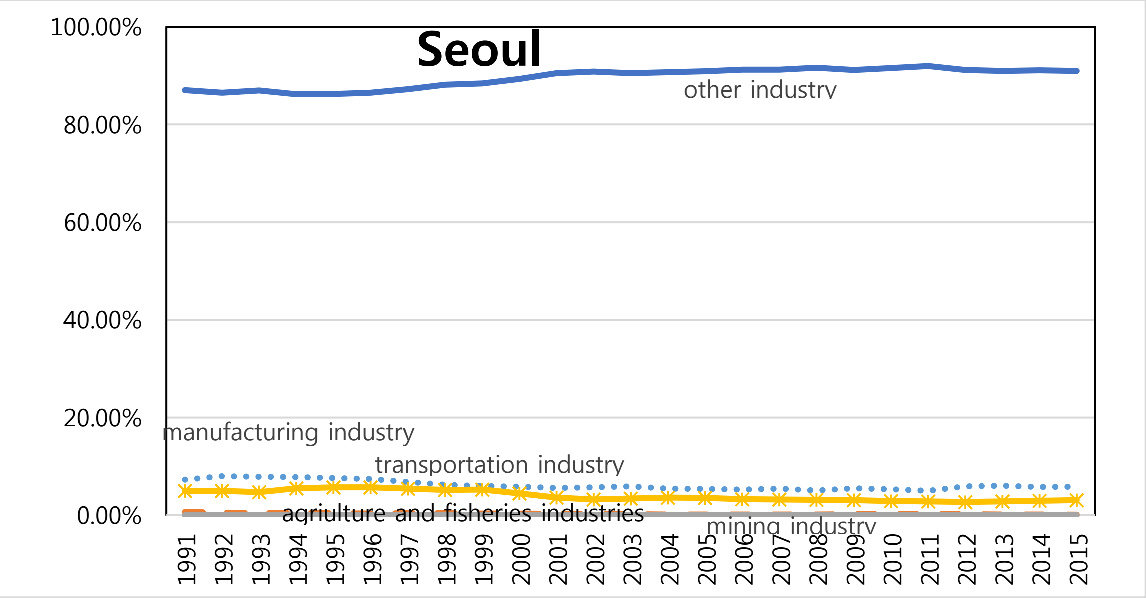

Figure 2.13: Ratios of each industry of Seoul, Korea

Source: Author's elaboration on the data of Statistics Korea (2017).

Seoul, the capital of Korea, is a main import/export hinterland for Busan Port, Incheon Port and Pyeongtaek Port. The main industries of Seoul are other industries including services, ranging from 87.0 % in 1991 to 91.0 % in 2011 (Figure 2.13). In Seoul, the ratio of manufacturing decreased continually from 7.3 % in 1991 to 5.8 % in 2015. The ratio of transportation also decreased overall from 5.0 % in 1991 to 3.1 % in 2015.

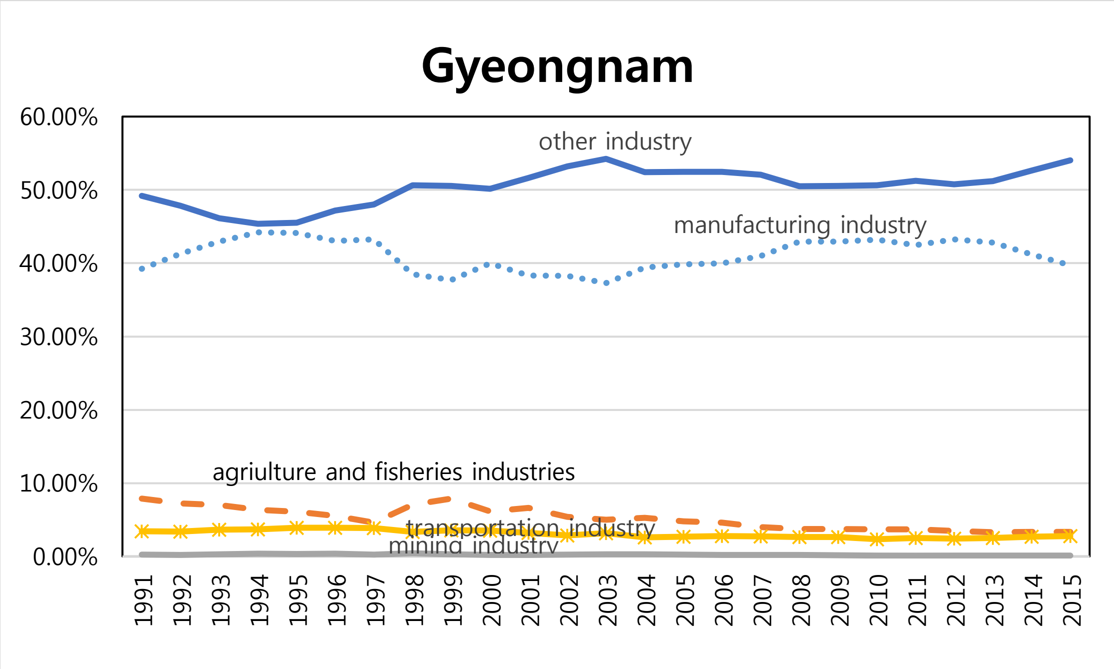

Figure 2.14: Ratios of each industry of Gyeongnam, Korea
Source: Author's elaboration on the data of Statistics Korea (2017).

Gyeongnam is another main import/export hinterland for Busan Port. Although the ratio of manufacturing in the regional production is higher than those of other regions, it fluctuated from 37.3 in 2003 to 44.1 % in 1995 (Figure 2.14). The ratio of transportation fell from 3.4 % in 1991 to 2.8 % in 2015.

The thesis explores the industrial structure of the identified main regions among the hinterlands of Korean ports. Port cities among them show different trends in the ratios of the transportation industry for regional production: Busan demonstrates trend of a decreasing ratio, but Incheon illustrates an increase. The manufacturing industries continue to be the leading industry in the Korean economy and are a main customer for Korean container ports.

2.2.3 Transshipment of Korean ports

When focusing on Busan Port, we can find that transshipment (T/S) activity has been a main driver in the growth of the container volume of the port. The transshipment activity of Busan Port has mainly been between Busan Port and Chinese ports, and between Busan Port and Japanese ports. Figure 2.15 shows that the total container throughput of Busan Port is dependent on transshipment. The container volume of transshipment at Busan Port increased from 70 thousand TEU with shares of 3.2% of the ports total container throughput in 1991 to 2.9 million TEU with shares of 36.5% in 2001 and 10 million TEU with shares of 51.9% in 2015. Transshipment containers are composed of mainly trade containers from China and Japan. For example, China transshipped 637 thousand TEU containers of exports in 2000 through Korean ports as shown in Figure 2.16: 615 thousand TEU through Busan Port, 21 thousand TEU through Gwangyang Port, and 1 thousand TEU through Incheon Port. Japanese regional ports also used Busan Port as a transshipment hub by moving 142 thousand containers through Busan Port in 2000.

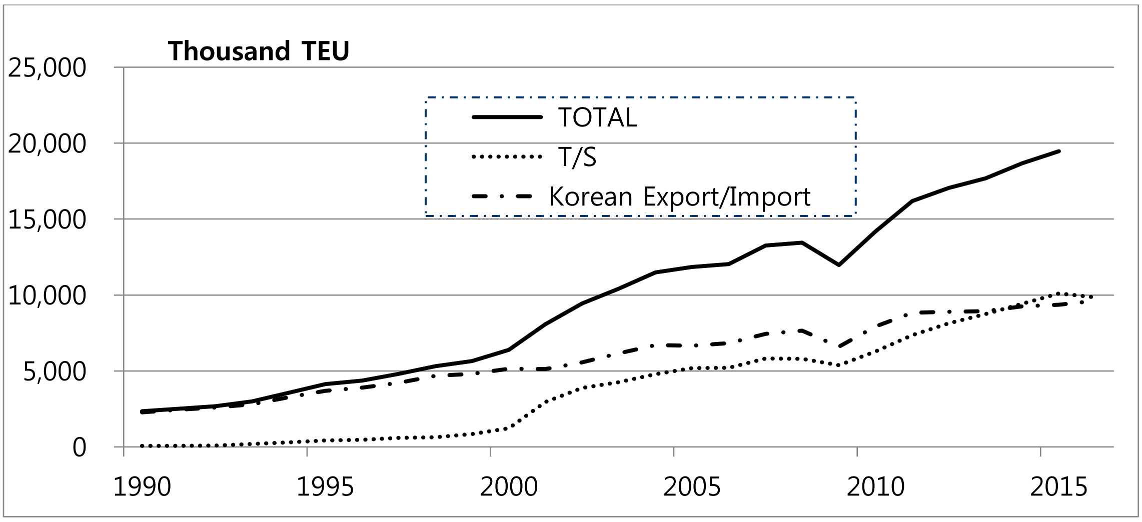

Figure 2.15: Container volume of Busan Port from 1990 to 2015

Source: Author’s elaboration on the data of MOF (2017).

Hence, the question of how Busan Port as a representative Korean port could attract transshipment containers from China and Japan is arisen. In North-East Asia Busan has been surrounded by major competitors when it comes to attracting transshipment. The major competitors have been Kobe port and Yokohama port in Japan in the early 1990s, Kaoshiung port in Taiwan in the 1990s, and Shanghai Port in China after 2000s all serving as a hub port in North-East Asia (Chang, 2000; Anderson et al., 2008).

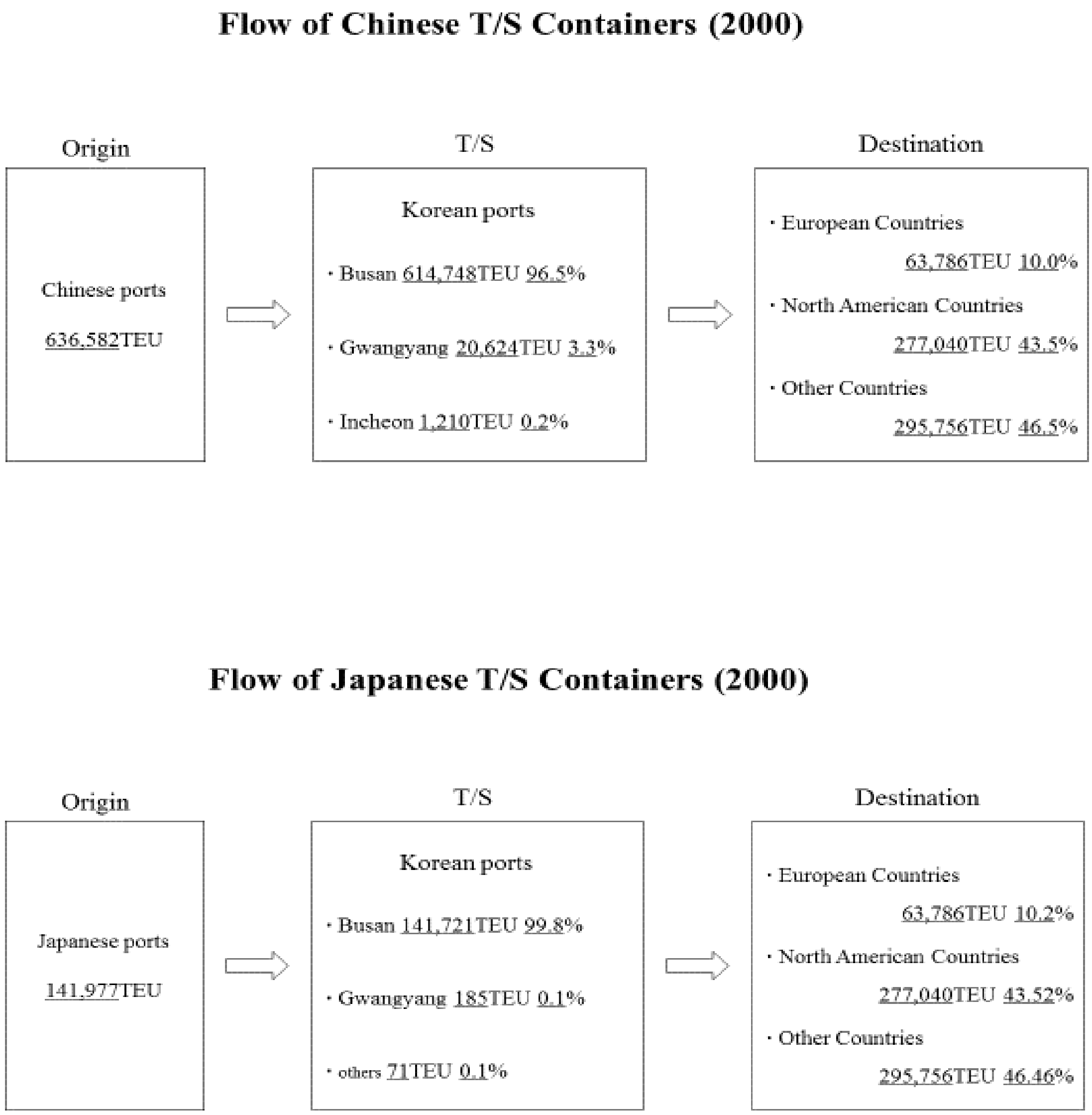

Figure 2.16: Transshipment of China and Japan export containers in Busan in 2000

Source: Author’s elaboration on the data of Korea Container Terminal Agency (2002)

Table 2.4 shows the number of foreign ports directly connected to Busan Port in each shipping route from the 1980s to the 2010s. In liner shipping, Busan Port was a regional small port providing direct connection with 9 foreign ports in North-East Asia in 1986. However, it started to enlarge its shipping network from the early 1990s, supplying more direct services to European ports and other foreign ports. It had a direct connection with 22 foreign ports in North-East Asia in 1991. The connectivity of Busan Port in North-East Asia jumped in the 1990s, increasing its direct connection from 46 foreign ports in 1996 to 122 foreign ports in 2001.

Table 2.4: Number of foreign ports directly connected with Busan Port in each shipping route

Year /Route	Inter-continental routes				Intra-regional routes			North-East Asia routes	Total
	NE	SE	NA	SA	SEA	ME	IS		
1986	10	20	16	29	18	17	9	9	128
1991	17	23	23	25	23	21	11	22	165
1996	18	34	33	28	30	23	13	46	225
2001	31	44	42	37	40	25	23	122	364
2006	39	35	44	41	43	32	25	139	398
2011	61	44	43	49	46	34	30	114	421

Source: Author's elaboration on the data of Korea Shipping Gazette (each year).
Note: NE: Northern Europe, SE: Southern Europe, NA: Northern America, SA: Southern America, SEA: South East Asia, ME: Middle East, and IS: India Subcontinent.

Hence, the analysis on the development of feeder shipping routes for Busan Port would explain the course of growth of Busan Port in North-East Asia and the relationship among the main ports in the region. Since Korea and China had not yet agreed a diplomatic tie and maritime agreement, Korean liners started to deploy container vessels in feeder routes to Japanese regional ports in the late 1980s after streamlining the Korean maritime industry in 1984 (Park and Choi, 2013). The commencement of direct shipping services agreement between Korea and China in 1989 promoted the development of feeder shipping routes for Busan Port. In addition, the Kobe 1994 earthquake helped Busan Port to attract more transshipment containers from Chinese ports and build a feeder network with Chinese ports (Chang, 2000).

3. Data and Methodology

3.1 Data

3.1.1 Data of manufacturing industries

The thesis gathers the annual data of Korean manufacturing establishments and plants collected by the Statistics Korea from 1991 to 2011, categorized in a two-digit industrial classification codes. The gathered data includes the panel data of enduring establishments from 1991 to 2011, the panel data of regional industrial complexes and the data of the total establishments surveyed by the Statistics Korea. The thesis is able to trace accurately each of the enduring establishments and industrial complex by individual identification codes. The data are composed of the statistics of manufacturing establishments, which employ 10 or more employees. Since industrial codes and administrative codes often change, the thesis adjusts the data to the codes in 2011.

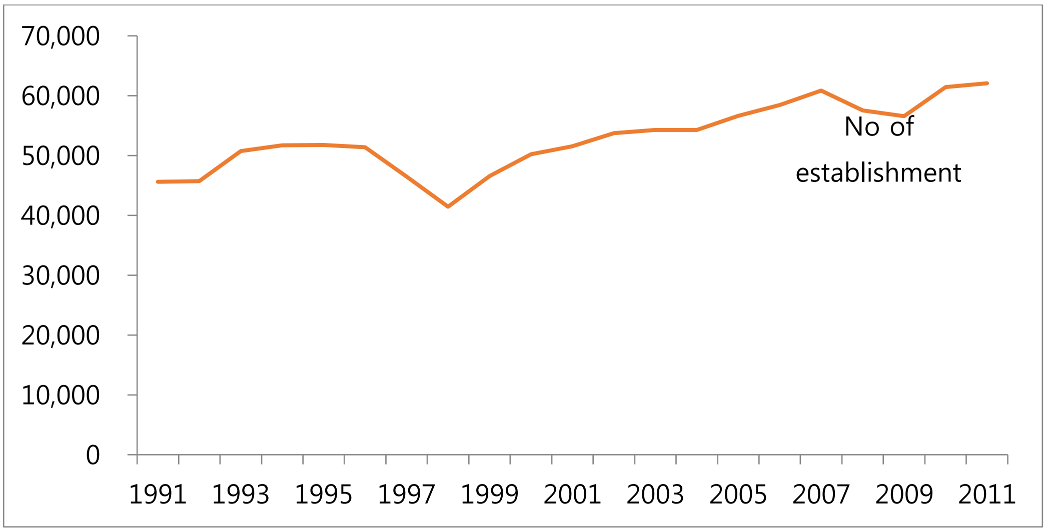

Figure 3.1: Number of establishment of Korea manufacturing industries

Source: Author's elaboration based on the data of Statistics Korea (each year).

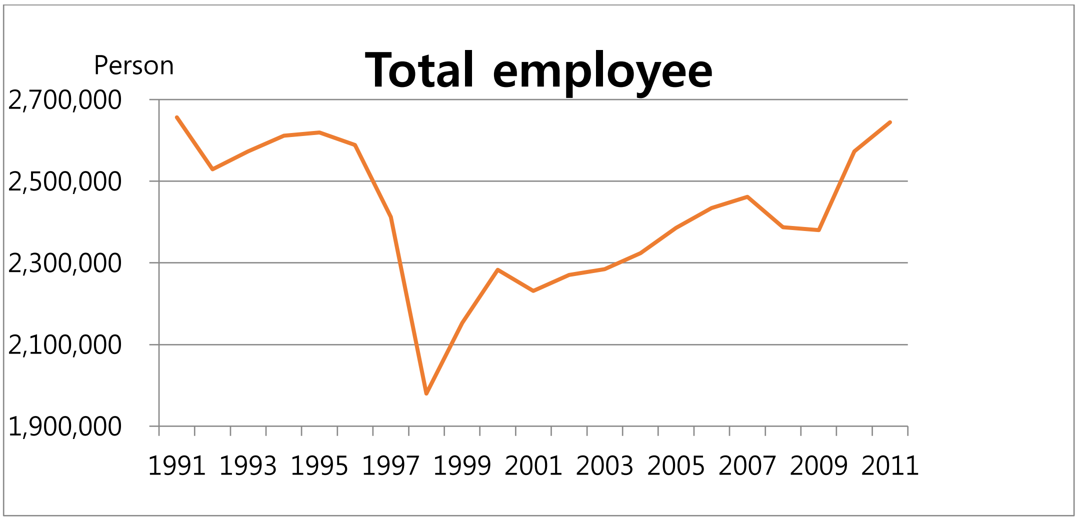

Figure 3.2: Number of total employees of Korea manufacturing industries
Source: Author's elaboration based on the data of Statistics Korea (each year).

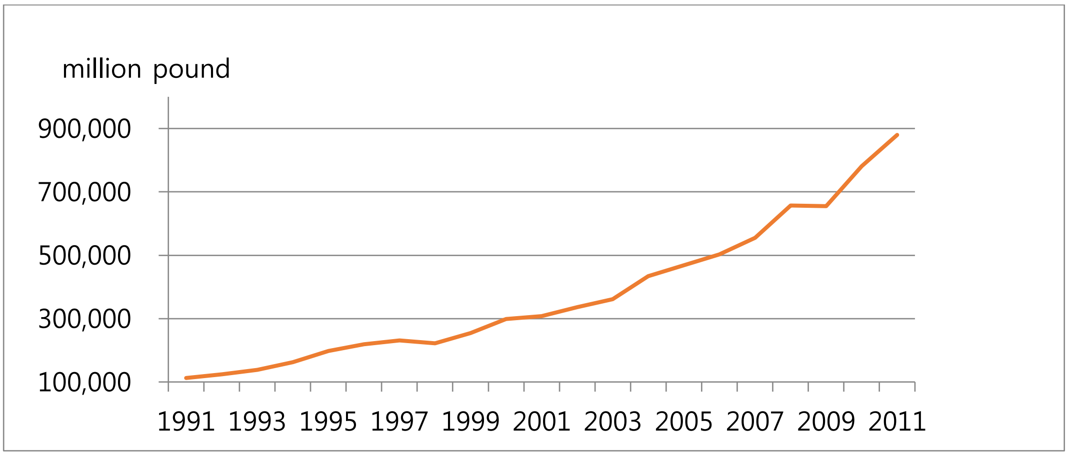

Figure 3.3: Amount of total production of Korea manufacturing industries (unit: million UK pound)
Source: Author's elaboration based on the data of Statistics Korea (each year).

The thesis has chosen the examined period in order to harmonize the data of manufacturing industries within themselves and with the survey on the data of origin and destination of containers of Korean ports. The survey on the data of origin and destination of containers is undertaken every five years by the Korea Transport Institute and the Korea Maritime Institute, including the year of 2011.

The manufacturing data include on average 53 thousand establishments employing 2.4 million persons and producing 37.6 billion UK pounds each year. The number of establishments as shown in Figure 3.1 increased incrementally from 45.6 thousand in

1991 to 62.0 thousand in 2011, with an exceptional decrease from 1996 to 2000 due to an unstable exchange market and the Korean economic crisis in the late 1990s. The figure of the manufacturing industries employees shows a slight fluctuation around 2.4 million persons during the 1990s (Figure 3.2). However, the unstable exchange market and following the Asian economic crisis post 1997 caused a decrease in the number of employees within the manufacturing industries. Even though the amount of total production in the manufacturing industries shows a little fluctuation as illustrated in Figure 3.3, it still shows growth, from 11.2 billion UK pounds in 1991 to 87.9 billion UK pounds in 2011.

The thesis uses the data of enduring industrial establishments, which were active from 1991 to 2011. The thesis ignores the establishments with blank information, removing them from the panel dataset. The number of the samples, which have empty data of tangible assets, was 1381, and only in 2010: almost 66% of total enduring establishments, contrary to the 11 missing cases in 2011. The thesis estimates the tangible assets at the samples with missing data in 2010. After deleting other samples in blank data elements, we get the sample of 2,092 establishments for the 21 years.

The thesis also builds on the panel dataset of each regional industrial complex by including the number of establishments within each complex, from 1993 to 2011. In 1993 there were 293 regional industrial complexes, sharing a total of 8,434 establishments, compared to 464 industrial complexes accommodating 112 thousand establishments in 2011.

The thesis uses additionally the data of an establishment's birth and exit in order to measure the regional effects of container ports on the leather, bag, and shoe industry in Chapter 5. Chapter 5 includes the calculation of the average age of establishments in some regions.

3.1.2 Maritime data and description

The main data source on shipping activity and port throughput is the Ministry of Oceans and Fisheries (MOF) of Korea and its official web site can be found at www.spidc.go.kr. The trade data are published by the Korea International Trade (KITA) and its website can be found at www.kita.net.

The statistics of MOF are composed of cargo throughput and container throughput moved by shipping companies in Korean ports, including cargo throughput of export and import, container throughput of export and import, and container throughput of transshipment. Furthermore, the thesis gathers the following data on container terminals from terminal operators and port authorities such as the Busan Port Authority: number of berth, outreach and tonnage capacity of quay cranes, length of berths and area of container yards. The thesis measures the mechanical handling capacity of each container port by counting the number of quay cranes and their handling capacity at each container port. While the data on container movement on each shipping route in Busan Port are collected in the period 1990 to 2011, the data of Incheon Port can only be collected in the period 1995 to 2011.

The throughput of containers in Korea is from two sources: first, the exports and imports of Korea and second, transshipment containers of neighbouring countries. The container throughput of Korea increased from 2.5 million TEU in 1990, to 10.0 million TEU in 2001, and to 21.6 million TEU in 2011, as shown in Figure 3.4. In 2014, the volume of transshipment containers surpassed the combined container volume of Korea exports (EX) and imports (IM).

The majority of the construction of port facilities in Busan (BS) was done in the mid of 1990s and the late 2000s. The berth length of container terminals in Busan Port increased from 5.8 km in 1990 to 9.1 km in 2000 and to 16.4 km in 2010 as shown in

Figure 3.5; area of container yards (CYs) from 817 thousand m^2 in 1990 to 6.7 million m^2 in 2010. Nevertheless, Incheon Port began construction of its main container facilities in 2000. The berth length of container terminals at Incheon Port increased from 0.5 km in 1990 to 2.5 km in 2010 as shown in Figure 3.6.

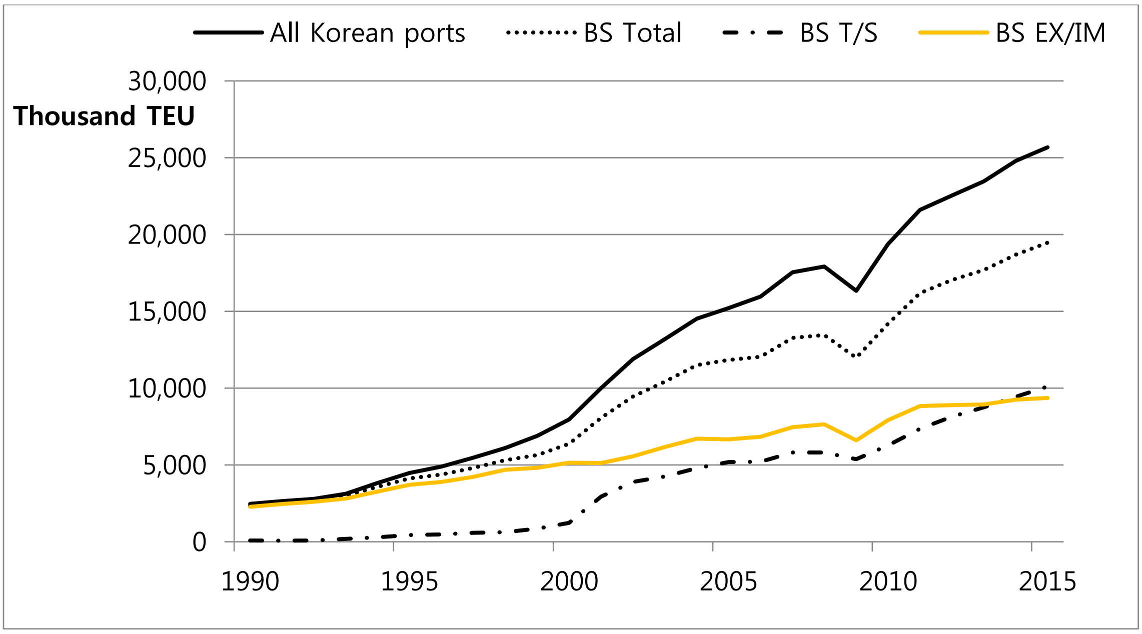

Figure 3.4: Container throughput of Korean container ports
Source: Author's elaboration based on the data of Ministry of Oceans and Fisheries of Korea (2017).

The number of quay cranes at Busan Port rose from nine in 1990, to 40 in 2001, and to 86 in 2011, as listed in Table 3.1: 44 super panamax cranes, 32 post-panamax cranes, and 10 panamax and other quay cranes in 2011. However, at Incheon Port, the number rose only slightly in the 1990s, but surged in the 2000s: 5 post-panamax cranes, and 14 panamax and other quay cranes in 2011.

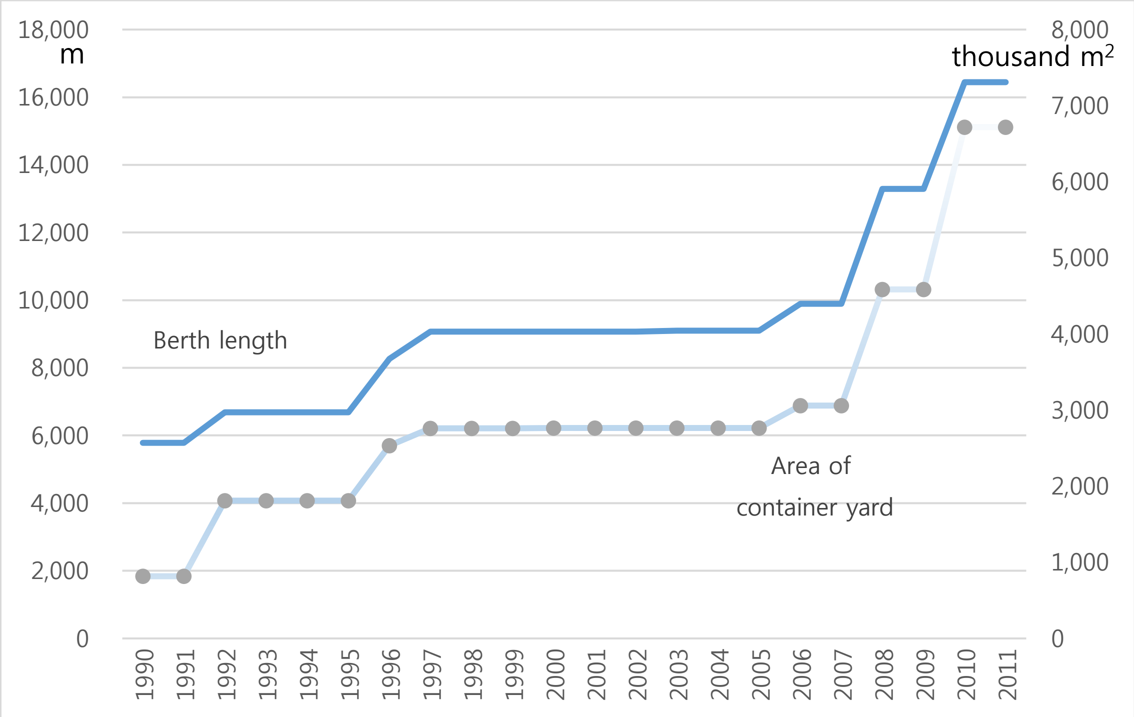

Figure 3.5: Berth length and area of container yards of Busan Port
Source: Author's elaboration based on the data of Ministry of Oceans and Fisheries of Korea (2017) and data of Busan Port Authority (2003-2016).

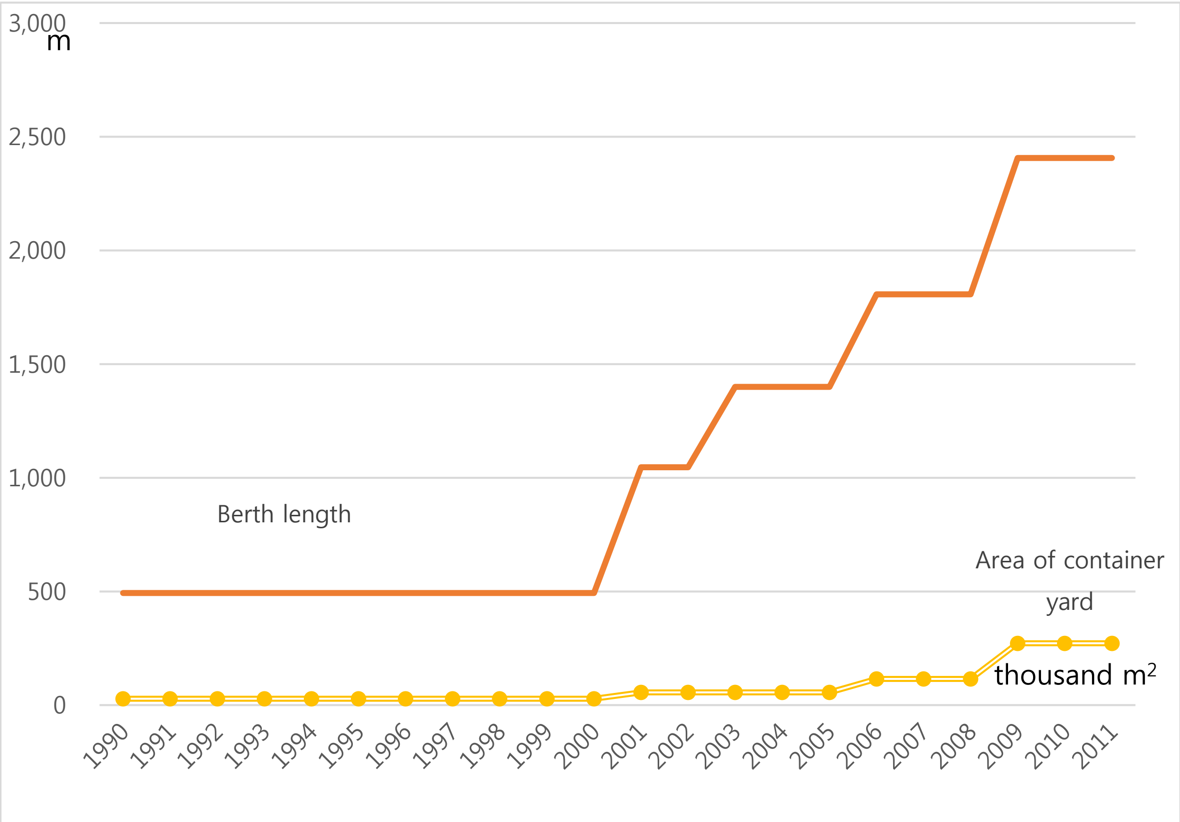

Figure 3.6: Berth length and area of container yards of Incheon Port
Source: Author's elaboration based on the data of Ministry of Oceans and Fisheries of Korea (2017) and data of Busan Port Authority (2003-2016).

Table 3.1: Number of quay cranes at Busan Port and Incheon Port

Crane/ Year	1990		2001		2011	
	Busan	Incheon	Busan	Incheon	Busan	Incheon
Super panamax	0	0	0	0	44	0
Post-panamax	3	0	31	0	32	5
Panamax and others	6	5	9	8	10	14
Total	9	5	40	8	86	19

Source: Author's elaboration based on the data of Ministry of Oceans and Fisheries of Korea (2017) and data of Busan Port Authority (2003-2016).

While considering the available dataset on a worldwide level, such as the data of Containerisation International (Informa UK, 2011) and Ports and Terminals Guide (Lloyds Register-Fairplay, 2010), the thesis considers a calculation method of handling capacity of containers at each container port. The method uses the data of quay crane number, mechanical handling capacity of quay cranes, length of quays, and area of container yards. Among these available data, the numbers and mechanical handling capacity of quay cranes give us the information on handling capacity of containers at quays in a container port. The others such as length of quays and area of container yards have difficulty in being standardized and counted globally for their handling capacity of containers.

Furthermore, besides the number of quay cranes of a container port, we could find the other facilities for loading and discharging containers in RO/RO berths and lighterage (transshipment between a vessel to another vessel) at some river ports or shallow ports (Turner et al., 2003). Since between these two facilities, a RO/RO berth with a mobile crane can load and discharge containers without a quay crane, we can count the productivity of one RO/RO berth as that of one mobile crane.

While considering the calculation method of UNCTAD (1985) and the suggestion of optimal utilization ratio of a berth in a container port by Park and Medda (2014), we can develop the following Equation 3.1 of handling capacity per day in a container port.

UNCTAD (1985; 1987) assumes that the ratio of operation time of quay cranes to the berthing time of ships is 0.8.

PC = 0.781 × 18 hour × (average movement per crane) × (number of quay cranes)

× (operation time of cranes/berthing time of ships)

= 0.781 × 18 hour × (average movement per crane) × (number of quay cranes)

× 0.8 (3.1)

Table 3.2: Different types of quay cranes and their capacity per a year

Crane		Optimum utilization ratio	Hour	Day	Average movement /crane/hour	TEU /van	Operation hour/ berthing hour	Yearly capacity (TEU)
Type	Container rows of a vessel							
Super post-panamax	21 & over	0.781	18	330	45	1.7	0.8	283,915
Post-panamax	15-20				40			252,369
Panamax	12-14				25			157,731
Mobile crane & other quay cranes	11 & under				22			138,803
Ship's gear and cranes at RO/RO berth					12			75,711

Source: Author's elaboration based on the data by Rankine (2003), Bartosek and Marek (2013), and Informa UK (2002).

Following the data of Rankine (2003) and analysis of quay cranes by Bartosek and Marek (2013), the thesis uses the mechanical movement capacity of quay cranes as shown in Table 3.2. If we consider that there are 330 working days at a container port (Chang et al., 2012) and one movement is approximately 1.7 TEU (Bartosek and Marek, 2013), as shown in Table 3.2, we get the annual capacity of each type of crane. Furthermore, the capacity of RO/RO terminal and multi-purpose terminal can simply be calculated to be the same level of ship's gear (Korea Maritime Institute, 2000a and 2000b; Rankine, 2003).

3.1.3 Causality between trade, container throughput and container handling capacity

The thesis faces the issue of causality between the variables of Korean trade amount and the port activity of Korea, and between container throughput and the container handling capacity of a port. Since the container throughput of Korean container ports includes transshipment from neighbouring countries, it indicates the trends of both Korean ports and the ports of neighbouring countries, such as China and Japan. While intermodal transport of containers includes essentially transshipment activity in a transport node such as a container port, transshipment at a port needs an efficient network between main trunk routes, and between main trunk routes and feeder routes (Fremont, 2007; Rodrigue and Ashar, 2016). For example, the shipping route between Busan Port and the Western or Eastern coastal ports of the USA are trunk routes, and the shipping route between Busan Port and Japanese regional ports are feeder routes. Hence, container throughput of a container port can indicate its shipping network in range of its network coverage and the number of routes. This section of 3.1.3 of Chapter 3 uses mainly the container throughput and handling capacity of Busan Port as indicators of Korean port activity, following the results of Table 4.2, which informs us the positive relationship between the container throughput of Busan Port and output of manufacturing industries.

The thesis tests the stationarity of data in time series by adopting a unit root test in the following different methods: without time trend and no lags, with time trend, and with a one-year lag. We choose one-year lag following the recommendation of Wooldridge (Wooldridge, 2009). Since the throughput of containers and handling capacity of a port and railroad tend to grow steadily in Busan, we find the unit root in all level variables and this means that the data are nonstationary. Nevertheless, the first difference of variables improves stationarity. Variables of first difference in Table 3.3 show stationarity at the 1% significant level.

The thesis also tests the long-run equilibrium relationship between variables by performing a cointegration test (Gujarati, 2006). There are long-run equilibrium relationships among the trade amounts of Korea, container throughput of Busan Port, and the handling capacity of containers at Busan Port, as demonstrated in Table 3.4.

Table 3.3: Augmented Dickey–Fuller unit root test and Z(t) value

	Levels			First-differences		
	Period :1972-2011			Period : 1972-2011		
	Ktr	conth	conca	Ktr	conth	conca
No trend and no lags	3.01 (-2.96)	3.33 (-2.96)	2.64 (-2.96)	-5.69*** (-2.96)	-4.57*** (-2.96)	-3.95*** (-2.96)
Including time trend	-1.03 (-3.54)	0.36 (-3.54)	-0.16 (-3.54)	-7.06*** (-3.54)	-5.94*** (-3.54)	-4.52*** (-3.54)
With trend & one year lag	2.12 (-3.54)	0.36 (-3.54)	-1.05 (-3.54)	-4.44*** (-3.55)	-6.49*** (-3.55)	-4.30*** (-3.55)

Note: 1) Ktr: Korean trade amounts; conth: container throughput of Busan Port; conca: handling capacity of containers of Busan Port
2) * significant at 10 percent level; ** significant at 5 percent level; *** significant at 1 percent level. The figures in parenthesis mean 5% critical value.
Source: Author's elaboration based on the data of MOF (2017), KITA (1972-2011), and Busan Port Authority (2003-2016).

Table 3.4: Cointegration test among variables

Rank/Variables	Ktr		conth
	conth	conca	conca
r=0	38.83 (15.41)	28.24 (15.41)	28.24 (15.41)
r≤ 1	5.21 (3.76)	6.83 (3.76)	6.83 (3.76)

Note: 1) The figures in parenthesis mean 5% critical value.
2) Ktr: Korean trade amounts; conth: container throughput of Busan Port; conca: handling capacity of containers of Busan Port.
Source: Author's elaboration based on the data of MOF (2017), KITA (1972-2011), and Busan Port Authority (2003-2016).

Since level variables have a unit root, we test the Granger causality of first-difference variables. We divide the period into three categories: the whole period from 1972 to 2011, the period from 1972 to 1990, and the period from 1991 to 2011. The period from 1991 to 2011 is the examined period for the effects of container ports on manufacturing industries in Korea. All variables record a continual increase, except the container throughput of Busan and trade amounts of Korea in 2009. Therefore, the Granger causality will test whether the increase of one variable informs the increase of other variable.

Table 3.5: Granger causality test

Period/Variables		Ktr and Conth		Conth and Conca	
		Ktr → Conth	Conth → Ktr	Conth → Conca	Conca → Conth
1972-2011	χ^2	37.53	35.63	10.44	14.37
	Prob. > χ^2	0.000	0.000	0.015	0.002
1972-1990	χ^2	173.82	150.16	2.65	0.88
	Prob. > χ^2	0.000	0.000	0.448	0.83
1991-2011	χ^2	18.28	24.03	5.01	6.85
	Prob. > χ^2	0.000	0.000	0.171	0.08

Note: Prob. means probability.
Ktr: trade amounts; conth: container throughput of Busan Port; conca: handling capacity of containers of Busan Port.

Source: Author's elaboration based on the data of MOF (2017), KITA (1972-2011), and Busan Port Authority (2003-2016).

First, trade amounts of Korea and container throughput of Busan Port have Granger causality with each other as described in Table 3.5. There is Granger causality on both sides. In addition, even when separating the period, we find Granger causality in both directions. Second, although container throughput of Busan Port and the handling capacity of containers in Busan Port show Granger causality in both directions from 1972 to 2011, there is no Granger causality between container throughput of Busan Port and the handling capacity of containers in Busan Port during the period of 1972 to 1990. There are two sources of container throughput of Busan Port: export and import of Korea, and transshipment containers of neighbouring countries. Figure 2.15 in Chapter 2 illustrates that Busan Port handled mainly containers of Korean export and import until the early 1990s and then it started to attract transshipment containers of Japan and China. Therefore, we conclude that although the Korean government developed and expanded its port facilities, Busan Port could not attract enough transshipment cargoes from neighbouring countries in the period of 1972 to 1990. Nevertheless, the Granger causality from the handling capacity of containers in Busan Port to container throughput of Busan Port in the period of 1991 to 2011 implies that the expansion of Busan Port has induced transshipment activity in Busan Port since the 1990s. Therefore, the hierarchical status of Busan Port within global shipping networks started to grow in the late 1980s and rose further in the 1990s.

To summarize, we can see that the trade amounts of Korea has a clear interaction with the container throughput of Busan Port. Even though the expansion of the port facilities at Busan Port and the increase of container throughput of Busan Port have generally Granger causality from 1972 to 2011, the expansion of port facilities of Busan Port has Granger causality with the increase of container throughput at the port, mainly after the 1990s.

3.2 Methodology

3.2.1 Container port, a hub of intermodal transport

Transportation plays a pivotal role in the development of industries (Ng and Gujar, 2009), by better enabling regional integration and the specialization and promotion of foreign trade (Krugman and Venables, 1996). This is even true for the economies of land-locked and lower accessibility countries (Behrens et al., 2009). In particular, ports have become the main 'promoters' of agglomeration and regional integration by helping economic players to share inputs, outputs and technology (Fujita and Mori, 1996; Funke and Yu, 2011). The development and expansion of any port yields both positive and negative regional effects: port development can lower transport costs and improve punctuality in both supply and procurement. This is likely however to promote the influx of foreign goods and intermediates such as parts and components, increasing competition with neighbouring regions and foreign countries (Stevens et al., 1981; Goss, 1990).

The thesis finds two different ways of evaluating the effects of a port on the local economy. The first approach rests on an Input-Output Table of the national economy. The amounts of output of a port, maritime, or transport industry are considered as a trigger of employment, production, and value added in other sectors (Jung, 2011; Kwak et al., 2005; Lee and Yoo, 2016). Although the method of an Input-Output Table is clear and simple when evaluating the effects of a port on the economy, it does not consider both the flows of cargoes and transport networks around a port. Furthermore, since the development of the port industry works as an additional demand in other industries in the Input-Output Table, the effects of a port on the economy are always positive with the Input-Output Table method. Hence, the method of Input-Output Table has a deficiency when it comes to the explanation of power for the diverse phenomena around a port, for example, the development of transshipment cargo handling in a hub port and a pure transshipment port, and the growth or downfall of manufacturing industries around a port.

Another approach stresses the positive regional effects through microeconomic models of production and employment, and macroeconomic models of economic growth (Acciaro, 2008; Bottasso et al., 2013; Bottasso et al., 2014; Shan et al., 2014; Park and Seo, 2016). The approach uses mainly aggregated regional economic variables, such as regional gross domestic product (RGDP) and regional employment. This approach provides us with useful aggregated effects, but no research that we are aware of gives specific effects on each industry, with their own peculiarities in their inputs and outputs, or their relationships with port activities. Furthermore, RGDP includes the product amount of diverse industries such as education, defense services, police services, medical services, the mining sector, and other sectors, which all depend less on a container port than manufacturing industries.

Since regional economies contain diverse industries and the port sector encompasses the multiple functions of a port, from pilotage of vessels to warehousing, the thesis tries to narrow the examination range of ports effect on the regional economy. While considering the generalization of intermodal transport around a container port since the 1960s and the great share of container cargo among the cargo tonnage of Busan Port, we can reduce the range of thesis analysis to the effects of container ports on the manufacturing industries in Korea.

The thesis adopts a microeconomic method of analysis and uses the data of each establishment within the manufacturing industries in Korea. Since the data of each establishment of production specify the detailed information of output and input at each business unit, the thesis can evaluate more precisely the effects of container ports on manufacturing industries and other phenomena within Korean container ports, such as a hub port development and transshipment activity.

3.2.2 Production function of manufacturing and the effects of a container port

The thesis faces an issue raised by the major question in Chapter 1: what is the basic role of a container port in a country or in a region, and how do we measure performance of a container port? The thesis can find three different views on the economic role of a port and the measurement method of port performance. This issue is related to the types of input indicating port activity in the production function of the manufacturing industries.

The first approach considers a port and a container port as a regional transport capital stock (Deng et al., 2013; Song and Geenhuizen, 2014). For example, Deng et al. (2013) interpret physical elements of a port, such as length of berth and port investment, as an indicator of port supply and examine first the positive effects of a port supply on the regional economy. The second examination is focused on the industrial activity and economic performance of a port in a region (Kwak et al., 2005; Acciaro, 2008; Jung, 2011; Lee and Yoo, 2016). The second approach tends to evaluate the economic contribution of a port in a region and a country mainly by adopting the Input-Output Table or surveying the economic effects. The third reviews the functioning of ports mainly in a shipping network (Chang, 2000; Lam and Yap, 2011; Rodrigue and Ashar, 2016).

These approaches do not consider simultaneously both shipping and inland transport networks. In addition, nowadays, a hub port and a gateway port may affect the regional economy and the national economy differently in proportion to the share of transshipment containers among ports container throughput. Hence, the thesis first considers total container throughput of a port as a good indicator of port status in the global shipping network. Then, the thesis tries to evaluate the effects of transshipment activity on a port while recognizing that a pure transshipment port can handle theoretically containers without domestic hinterlands, If a container port handles more containers, the port can expand and improve its facilities such as quay crane, berth, container yard, and other equipment. The expansion of port facilities may attract larger vessels and then enhance the efficiency of a port operation. For example, a quay crane of super post-panamax is twice efficient in loading containers to/from container vessels than a mobile crane as shown in Table 3.2. The mechanical capacity of each type of quay crane as shown in Table 3.2, movement of container van per hour, clearly demonstrates the improvement of efficiency in loading and unloading containers in a container port. Therefore, container throughput is chosen at times as an indicator of port activity on the literature of ports regional effect (Deng et al., 2013; Park and Seo, 2016; Shan et al., 2014). Nevertheless, there is an argument against cargo throughput as a proper indicator of port performance (Langen and Sharypova, 2013). Hence, the thesis first uses container throughput as an indicator of development of container ports and later, divides container throughput of a port into two different types of containers in accordance with domestic hinterlands: containers of Korean export and import; and transshipment containers from neighbouring countries.

Port development in proportion to the increasing container throughput of a container port can be considered as a kind of technological development. Table 3.1 shows us a technological advancement of quay cranes in the two main container ports in Korea, Busan and Incheon. A few papers on evaluation of effects of a port on regional economy choose cargo throughput and container throughput as an indicator of development of transport infrastructure. Bottasso et al. (2013) test the effects of cargo throughput and passenger number of a port on regional employment in ten European countries. Bottasso and Conti (2009) use Cobb-Douglas function with a factor of transport infrastructure when they evaluate the effects of road transport liberalization in 11 EU countries.

The basic idea of the evaluation of a ports effect on the economy, especially the regional economy, comes from the review of technical change and its effects on aggregate production function by Solow (Solow, 1956; Solow, 1957). Solow considers technical change as any kind of production improvement such as the improvement in the education of a labourer and assumes that technical change works neutrally and shifts the production function of the output under given inputs at his basic model as shown in the following Equation 3.2.

$$Y = A(t)\,F(L, K) \tag{3.2}$$

Where,

Y: output of production,

A(t) : measurement of the accumulated effect of shifts of production over time,

t: time,

L: labour input,

K: capital input.

Solow’s macroeconomic growth model focuses on the interpretation of economic growth with exogenous technological progress in a nation (Chu, 2018). The model adopts national product as a proxy of aggregated output in the aggregate production function (Solow, 1957). Solow (1957) tests a few types of aggregate production function including Cobb-Douglas function in the analysis of the economic growth of the United States during the period of 1909 to 1949. Park and Seo (2016) evaluate effects of seaports on the regional economic growth in Korea while using the Solow model. Although the Solow model is useful to understand the role of technological progress in economic growth, the thesis needs a microeconomic model to analyse the effects of container port on manufacturing industries in Korea. Furthermore, the thesis collects mainly the panel data of each manufacturing establishment. Hence, a microeconomic model of production function is suitable for analysing the relationship between a container port and the manufacturing industries in Korea. While following the method of Solow’s model and regarding the externality of port development on regional economy, the literature on the evaluation of a ports effect on the regional economy or wider economy tends to adopt the format of Cobb-Douglas production function (Cobb and Douglas, 1928; Bottasso et al., 2014; Shan et al. 2014; Song and Geenhuizen, 2014).

Cobb-Douglas production function is generally referred in the textbooks of econometrics (Gujarati, 2003; Greene, 2008; Maddala, 2004). Cobb and Douglas (1928) used a log-linear function in order to estimate the growth of American manufacturing by the factors of labour and capital from 1899 to 1922, and to analyse the distribution shares of the two factors. They assumed that the production function could be characterized by constant returns to scale and the distribution shares are decided by the marginal productivity of the two factors.

Criticisms on Cobb-Douglas production function focused mainly on the two points. First, their assumption of constant returns to scale is too limited and simple to explain the production in real industries (Labini, 1995; Samuelson, 1979). Second, the tendency of technical progress, an important element of economic development, is not considered in Cobb-Douglas production function (Samuelson, 1979). Nowadays, the textbook of econometrics tends to allow economies of scale of production function to change with output (Greene, 2008; Gujarati, 2003). Moreover, an aggregate production function as in the case of study by Solow (1957) adopts additionally a factor of technical progress (Felipe and Adams, 2005; Samuelson, 1979).

The thesis develops a type of Cobb-Douglas production function from Equation 3.2 and replaces the technical change with an indicator of port development, listed in Equation 3.3.

$$Y = B(pa)\, L^{\alpha} K^{\beta} \qquad (3.3)$$

Where,

Y: output,

B(pa): measurement of effect of port development, pa: an indicator of port development such as port infrastructure capital stock, cargo throughput, container throughput, and container handling capacity of a port.

If we consider multiple inputs, we can develop a log-linear regression model including a number of variables. The coefficient of each independent variable in a log-linear regression measures the elasticity of dependent variable Y with respect to that independent variable (Gujarati, 2003). The thesis starts to develop a production function, which contains one output and three inputs as shown in Equation 3.3.

First, the thesis divided capital into two different types in accordance with their role in the process of production in order to construct a production function of multiple inputs: machinery and buildings, and raw materials as a working capital (Cobb and Douglas, 1928). The thesis does not include the inventory of goods in the production function, which include goods in production process and finished goods in warehouse because these two goods do not contribute directly to the change of production. Second, road development also might promote the domestic trade and foreign trade, and lowers transport costs of goods. Hence, the thesis adds an indicator of road development as a technical progress in an economy. Third, the thesis considers a factor of dependence of Korean economy on export and import. The openness indicator of economy, which is measured as a ratio of combined export and import to nominal GDP, has been over 40% in the 1990s, 2000s, and the early 2010s (Milani and Park, 2015). Milani and Park (2015) observed that the effects of open-economy variables such as terms of trade and exchange rate rose during the period from 1990 to the early 2010s. Hence, the thesis adds an indicator of comparative competitiveness of Korean manufacturing in production function.

We can use a Cobb-Douglas production function that includes inputs such as labour, capital, intermediates (parts and components), container throughput of a port, the global competitiveness index of Korean manufacturing industries, and an indicator of other transport infrastructure such as the roads in each region. Since manufacturing industries face the diverse effects of globalization in production and the sales of production, the thesis includes the variable of global competitiveness index in the production function. The thesis uses a Cobb-Douglas production function, which contains one output and multiple inputs as shown in Equation 3.4 (Greene, 2012; Shan et al., 2014; Song and Geenhuizen, 2014).

$$Y = (pa)^{a1} (ma)^{a2} L^{a3} K^{a4} M^{a5} R^{a6} \quad (3.4)$$

Where,

Y: output or value added at each manufacturing establishment,
pa: an indicator of port development such as port infrastructure capital stock, cargo throughput, container throughput, and container handling capacity of a port,
ma: global competitiveness index,
L: labour input, wages as a proxy,
K: capital input, multiplication of tangible assets and yield of corporative bonds,
M: intermediates for production,
R: length of road.

Labour input in production function indicates hours of labour in the textbook of microeconomics (Nicholson, 1983). The data on Korean manufacturing by the Statistics Korea do not include the information on hours of works in a factory but average employees per a month and annual wages. Furthermore, correlation coefficient of employment with output of regional manufacturing industries in Table 4.2 of Chapter 4 is 0.11, indicating no correlation and lower than correlation coefficient of wages with output, 0.70. The number of labourer in the panel data of Chapter 5 and Chapter 6 also show lower correlation coefficients with output than those of wages with output in Table 5.2 and Table 6.2. The thesis selects wage as a proxy for labour input. The length of road is selected as an indicator of other transport infrastructure (Fageda and Gonzalez-Aregall, 2017).

From Equation 3.4 we get the log linear production function as illustrated in the Equation 3.5.

$$\ln Y = a1 \ln pa + a2 \ln ma + a3 \ln L + a4 \ln K + a5 \ln M + a6 \ln R \quad (3.5)$$

The thesis collects the panel data of each manufacturing establishment and each industrial complex, and the panel data can give us detailed information of each business unit in manufacturing. We can observe the data of each establishment on output, physical capital such as machinery and buildings, and raw materials in the examined period from 1991 to 2011. Furthermore, the panel data in the thesis contain the cross-sectional and time-series information of samples. Hence, the thesis can develop an equation suitable for the panel data of Korean manufactuing, as shown in Equation 3.6. Equation 3.5 can be transformed into the format of each establishment i in year t as shown in the Equation 3.6.

$$\ln Y_{it} = a1 \ln pa_{it} + a2 \ln ma_{it} + a3 \ln L_{it} + a4 \ln K_{it} + a5 \ln M_{it} + a6 \ln R_{it} \quad (3.6)$$

In addition, we add disturbance term, ε_{it} into Equation 3.6. Then Equation 3.6 is changed into Equation 3.7.

$$\ln Y_{it} = a1 \ln pa_{it} + a2 \ln ma_{it} + a3 \ln L_{it} + a4 \ln K_{it} + a5 \ln M_{it} + a6 \ln R_{it} + \varepsilon_{it} \quad (3.7)$$

Equation 3.7 takes the format of panel data model. Equation 3.7 can be extended into different types of panel data model in accordance with characteristics of variables and disturbance term.

3.2.3 Statistics program

The thesis mainly uses STATA (Statistics Data Analysis) 14 program in order to handle data and calculate correlation between variables (Adkins et al., 2011). Since the thesis collects the panel data of Korean manufacturing industries from the Statistics Korea, Korean statistics office, and the panel data of ports of Busan, Incheon, Rotterdam and Felixstowe, the thesis generally adopts panel data models of econometrics and STATA program in Chapter 4, Chapter 5, Chapter 6, and Chapter 8. The thesis uses a linear regression in calculating coefficients of independent variables in panel data models.

4. Korean Container Ports and Regional Manufacturing Industries

4.1 Introduction

In the previous chapters, we have observed that manufacturing industries are the main customers of container ports in Korea. We can see that, larger Korean container ports are located in central areas of a region such as Busan Port in the Busan Metropolitan City and Incheon Port in the Seoul Metropolitan Area (SMA). Here, they are in the heart of diverse industrial complexes that have existed since the 1960s, the starting age of industrialization in the Korean economy (Jung, 2011). These two metropolitan areas accommodate 247 of the total 1,124 industrial complexes in Korea in 2015 (Korea Industrial Complex Corporation, 2017). The industrial complexes in the two regions provide 601 thousand jobs and export 61.6 billion dollars of goods a year (Korea Industrial Complex Corporation, 2017). Korean ports support industrial complexes in exporting their goods and importing raw materials, which in Korea are mostly transported by shipping (Jung, 2011).

Although Korean container ports have grown in accordance with the economic development in Korea, Korean container ports have tried to attract foreign customers. In the early 1990s, Korean experts on maritime industry and the Korean government planned to expand port facilities in order to collect transshipment containers from neighbouring countries such as China, Japan, and Russia (Jun et al., 1993). In addition, the 1995 Kobe earthquake helped Busan Port to enhance its role of transshipment hub in North-East Asia (Chang, 2000).

The throughput of transshipment containers increased from 70 thousand TEU in 1991 to 3.1 million TEU in 2001 and to 10.7 million TEU in 2015 (Ministry of Oceans and Fisheries of Korea, 2017). As Grobar (2008) finds an economic decline in the port district near container ports in the U.S., the growth of transshipment containers of Korean ports might diversify the relationship between Korean container ports and the regional and the national economy in Korea.

Using the regional panel data of Korean manufacturing industries from 1991 to 2011 described in Chapter 3, Chapter 4 tests the effects of container ports on the manufacturing industries in a region. Since Busan Port has been a main container port and handled 95.5% of the total Korean container throughput in 1991 and 74.9% in 2011, Chapter 4 focuses on the regional effects of both a regional port and Busan Port. In addition, Chapter 4 also explores the question of whether the development of a container port varies the regional effects on the manufacturing industries by period and by region.

This Chapter is constructed as follows. Section 2 reviews the literature on the relationship between a port and manufacturing industries. This Chapter includes a description of the regional panel data and methodology in Section 3. Section 4 illustrates panel data models and the main results, and includes the robustness check of main results and the moderating effects between the main variables. Section 5 explores the basic question of whether the effects of a container port vary in accordance with period and region. The Section divides the examined period from 1991 to 2011 into the two periods: the first period from 1991 to 1998, and the second period from 1999 to 2011. Section 5 then examines different results by dividing the examined regions into the two: port cities with a big port. Busan and Incheon, and other regions without a big port. Section 6 concludes the Chapter.

4.2 Literature review

The literature on ports and their economic effects tends to emphasize the lowering of trade costs. Goss (1990) argues that an efficient port brings benefits to both producers of goods and consumers in the region by lowering transport costs, and that an economical transport network may help to diversify and specialize the regional industries. Goss's argument is similar to the literature on transport, which typically stresses the lowering of transport costs when a port or transport network develops (Fujita and Mori, 1996). Regional approaches on the effects of transport infrastructures are apt to consider transport as a public capital stock of the region and emphasize the effects of lowering the transport costs (Fageda and Gonzalez-Aregall, 2017; Lee and Yoo, 2016). Furthermore, in some cases, geographical location varies the pattern, contents and amounts of trade as shown in land-locked countries, where being landlocked raises transport costs of traded goods and hinders the growth of the economy (Gallup et al., 1999; Limao and Venables, 2001).

While the literature seems to point out the importance of a port in world trade by lowering transport costs, the thesis further explores the relationship between container ports and the regional economy. Since the efficient development of container ports not only lowers transport costs but also enlarges and improves the procurement and production network in each firm or each establishment. The phenomena of international division of production and economic integration of regional countries in North-East Asia, for example the international cooperation of automobile and automobile parts industries between Korea, China and Japan through container ports as described in Guerrero and Itoh (2017) and Koo (2013), demonstrate the diverse effects of container ports on the regional and national economy.

Meanwhile, the globalization of production and consumption in an economy needs an efficient port operation and intermodal transport in order to link different inputs and skills sometimes across long distances in the thousands of km (Kherbash and Mocan, 2015). While considering the role of intermodal transport in globalization, the thesis will evaluate the development of container ports as a facilitator within a network of procurement and production for manufacturing. This approach is different from the literature, which insists the role of a port and a container port as only lowering transport costs. As Diaz-Madronero et al. (2017) review the integrated decision model of production and procurement transport within the automobile industry, transport services are a vital part of the production of manufacturing. Since a container port supplies a diverse range of different networks to customers such as manufacturers, liners, and freight forwarders, the thesis can assert that the container port might affect the networking of production for manufacturers and the relationship between the different output and inputs in the production process.

The effects of container ports on manufacturing in Korea can be examined by using a simple production model of microeconomics. Generally, the literature on a port and its regional effects uses the production model, similar to the aggregated production function suggested by Solow (1957). Solow’s model aimed at tracing technological advancement and its contribution to national production.

4.3 Data description and panel data models

4.3.1 Data description

Regional panel data of Korean manufacturing industries in this Chapter include the data of 2,092 manufacturing establishments, which endured from 1991 to 2011 and data on container ports in Korea. We divide 2,092 establishments into 16 regional groups in accordance with 16 administrative regions in Korea. Hence, the regional panel data contain the manufacturing data of 16 administrative regions during 21 years from 1991 to 2011. We have a panel data on 336 observations.

The data on production activity of manufacturing issued by the Statistics Korea include the first information on production such as outputs and inputs of wages, tangible assets, and intermediates such as parts of goods. The data on ports issued by the Ministry of Oceans and Fisheries (MOF) show indicators of container ports such as container throughputs, cargo tonnage inside containers, and characteristics of Korean container ports such as the number of quay cranes, length of berth, and area of yard. Table 4.1 illustrates minimum, maximum, mean, and standard deviation of data of 16 regions.

Table 4.1: Summary of panel data of 16 regions of manufacturing industries

Item	Min	Max	Mean	Standard deviation
Output (M. Korean won)	5,431	1.14e+08	9,506,900	1.52e+07
Wages (M. Korean won)	522	3,796,261	476,472	625421
Intermediates (M. Korean won)	2,058	9.5e+07	5,614,774	1.09e+07
Tangible assets (M. Korean won)	1,139	2.36e+07	2,824,271	4,385,782
Port throughput (Thousand TEU)	0	15,523	625.7	2115.3
Port capacity (Thousand TEU)	0	22,448	1,068.8	3,196.6
Port throughput of Busan Port (Thousand TEU)	2,587	15,523	7,832.9	3,689.4
Port capacity of Busan Port (Thousand TEU)	3,293	22,448	11,460	5,366
Index of export market penetration	9.1	21.6	16.7	3.9

Note: Some regions show non-existence of the industry.
Source: Author's elaboration of the data of Statistics Korea (1991-2011), Ministry of Oceans and Fisheries of Korea (2017), and World Bank (2017).

This Chapter mainly uses output as a dependent variable. Main independent variables are indicators of port and road development, labour, capital, intermediates, and indicator of relative competitiveness of Korean manufacturing.

The data of the Statistics Korea do not include the information on working hours of labour. The thesis considers the number of workers, and wages and salaries of employees as an indicator of labour input. Workers comprise the employees, working proprietors and unpaid workers on a monthly basis (Statistics Korea, 2013). The thesis uses generally wages as a proxy of labour input. The thesis does not divide workers into production workers and nonproduction workers or skilled workers and unskilled workers due to lack of the exact data (Foster et al., 2001; Pavcnik, 2002).

Capital as a stock is used in the process of production in the form of tangible assets such as land, machinery, equipment, building, and others (Statistics Korea, 2013). The usage of capital input when producing output can be measured by the multiplication of quantity of capital services and the rental prices (Wang and Szirmai, 2012). Wang and Szirmai (2012) suggest that the sum of discount rate and depreciation rate would be an indicator of unit price of capital. OECD recommends that the quantity of service flows of capital would be measured by the three elements: rate of return to capital, depreciation and revaluation or holding gains (OECD, 2009). Nevertheless, the data on manufacturing of the Statistics Korea do not include discount rate and depreciation rate. Hence, the thesis uses multiplication of tangible assets and yield of corporative bonds as capital input.

Port activities are considered to shift the production function of each establishment and therefore affect regional output (Bottasso et al., 2014; Shan et al., 2014). Furthermore, since a regional manufacturer is exposed to global competition and life cycle of goods, we add an additional variable of global competitiveness of Korean manufacturers. We use the index of export market penetration calculated by the World Bank (2017) as an indicator of global competitiveness of Korean manufacturers. The World Bank (2017) describes the index of export market penetration as in the following:

It is the share of the actual number of export relationships (at the country product level) forged by Country A in the maximum possible number of export relationships it can form given the number of its exports. The denominator is calculated by summing the number of countries that import each product that Country A exports.

Since some regions in Korea have no container ports, those regions have the naught value in port throughput and port capacity. We have changed a stock variable, tangible assets, into flow variable by multiplication of tangible assets and yield of corporative bonds. Furthermore, this Chapter considers the effects of other transport infrastructures on manufacturing industries. Since Korean railways have shown a slight increase of length from 3,091 km in 1990 to 3,559 km in 2011 (Korean National Railroad, 1991-2011), we adopt the road length including express highway, local road and other roads as an indicator of development of other transport infrastructures, which extended its length from 56,715 km to 105,931 km during the same period.

4.3.2 Questions and panel data models

This Chapter explores the following questions.

- Whether a container port in Korea affects regional output of manufacturing industries?
- Does a container port in Korea affect regional output of manufacturing industries differently, in accordance with port development?
- Are there moderating effects between port activities such as container throughput and other variables such as labour, intermediates, and tangible assets?
- Does transshipment affect the regional output of manufacturing industries?

This Chapter adopts panel data models in order to examine the regional effects of Korean container ports. Since the thesis collects the panel data of the production activity of each manufacturing establishment in Korea, the thesis uses the production function of microeconomics. The thesis finds a basic production function of log-linear format in the literature of microeconomics, which includes output and inputs of production (Cobb and Douglas, 1928; Gujarati, 2003; Greene, 2012). Greene expanded the Cobb-Douglas production function including one output and two inputs into the production function containing one output and multiple inputs (Greene, 2012). The Cobb-Douglas production is widely used in tracing the effects of transport infrastructures on regional economies (Alvarez-Ayuso et al., 2016; Arbues et al., 2015; Cantos et al, 2005; Shan et al., 2014). From the assertion that the development of a port lowers transport costs by Goss (1990) and Fujita and Mori (1996), this Chapter builds a Cobb-Douglas production function, which includes output, inputs of each establishment, indicator of container port development and other variables.

This Chapter uses Cobb-Douglas production function and the following empirical model as a basis.

$$y = a1 + a2\ l + a3\ k + a4\ im + a5\ pt + \varepsilon \tag{4.1}$$

In Equation 4.1 y, l, k, im, and pt represent natural logarithms of variables of output, wages as a proxy for labour input, capital input, intermediates, and port throughput in year t. Equation 4.1 includes disturbance term, ε. We explore the moderating effects by introducing interaction variables of the normalized values of container throughput, wages, intermediates, and capital inputs.

Although Equation 4.1 informs the production of manufacturers in Korea, it does not tell us the effects of global competitiveness of Korean manufacturers on output of manufacturing industries. If a manufacturer has low competitiveness compared with foreign competitors in a global economy, it may lose domestic and foreign markets. Hence, we add an indicator of global competitiveness of Korean manufacturers. Since the thesis cannot find a long period data of revealed comparative advantage (RCA) for Korean manufacturers in the existing literature, the thesis uses the index of export market penetration calculated by the World Bank (2017).

The thesis adds moderators between container throughput and intermediates, capital inputs and wages into Equation 4.1. Moderators indicate an interaction effect between variables (Ali et al., 2016; Yang and Park, 2014; Yuen et al., 2016). Then Equation 4.1, a production function is changed into Equation 4.2 with a moderator, natural logarithm of the index of the export market penetration, and natural logarithm of road length at each region.

$$y = a1 + a2\, l + a3\, k + a4\, im + a5\, pt + \Sigma\, a6_m\, INT_m + a7\, ep_t + a8\, rd_t + \varepsilon \qquad (4.2)$$

Where,

INT_m: a moderator between normalized variables of container throughput, intermediates, capital inputs and wages,

ep_t: natural logarithm of index of export market penetration in year t,

rd_t: natural logarithm of road length at each region in year t.

Table 4.2: Correlation coefficients between variables

Variable	output	portth	bsportth	wages	intm	tanyield	emp
output	-	-0.042	0.310	0.704	0.965	0.392	0.110
portth	-0.042	-	0.157	-0.038	-0.028	-0.117	0.048
bsportth	0.310	0.157	-	0.233	0.303	-0.267	0.098

Note: portth; container throughput of a regional port; bsportth: container throughput of Busan Port; intm: intermediates; tanyield: yield of tangible assets; emp: employment.
Source: Author's elaboration of the data of Ministry of Oceans and Fisheries of Korea, and Statistics Korea.

This Chapter considers the different indicators of port activity: container throughput of the regional container port, container throughput of Busan Port as a hub port in Korea, and the cargo tonnage inside containers. While the container throughput of the regional container port shows no or weak negative correlation coefficients with output, wages, capital inputs, and intermediates, the container throughput of Busan Port illustrates a weak positive correlation with a few of them (Table 4.2). In addition, the port facilities as a stock cannot inform exactly port activity in a year. Hence, this Chapter uses mainly container throughput of Busan Port as an indicator of port activity.

4.3.3 Suitability of models

The linear regression model in the thesis is the most basic and useful model in econometrics when we analyse the relationship between a dependent variable and one or more independent variables (Greene, 2008). The general format of linear regression model is as follows.

$$Y = F(X_1, X_2, \dots, X_n) + \varepsilon$$
$$= a1\, X_1 + a2\, X_2 + \dots\dots + an\, X_n + \varepsilon \qquad (4.3)$$

Where,

Y: dependent variable,

$X_1, X_2, \dots, X_n$: independent variables,

ε: random disturbance.

We have observation in a sample of i^{th}, as shown in the following Equation 4.4.

$$Y_i = a1\, X_{i1} + a2\, X_{i2} + \dots + an\, X_{in} + \varepsilon_i \qquad (4.4)$$

The classical linear regression model has a few assumptions on the random disturbance in order to identify the independent effects of variables on a dependent variable (Greene, 2008). Greene (2008) describes those assumptions as in the following.

The expected value of the disturbance at observation i in the sample, ε_i *is not a function of the independent variables observed at any observation, including this one.*

This assumption is described in the following Equation 4.5 (Greene, 2008).

$$E[\varepsilon_i \mid X_{j1}, X_{j2}, \ldots\ldots, X_{jn}] = 0 \quad (4.5)$$

Greene (2008) explains another assumption as in the following.

Each disturbance, ε_i *has the same finite variance,* σ^2*, and is uncorrelated with every other disturbance,* ε_j*. The disturbances are normally distributed.*

The basic equation of the panel data model with an individual effect of a panel in year t is a linear regression model as shown in the following Equation 4.6 (Greene, 2008).

$$Y_{it} = a1\, X_{i1t} + a2\, X_{i2t} + \ldots + an\, X_{int} + c_i + \varepsilon_{it} \quad (4.6)$$

The heterogeneity or individual effect of i^{th} sample in Equation 4.6 is in c_i. The term of c_i contains a constant term and a set of individual or group specific variables, which might be observed, such as number of patent, or unobserved, such as processing knowhow and individual heterogeneity in skills or preferences. Panel data enable us to test some issues that cannot be explored in either cross-sectional or time-series data alone, and to use a diverse type of modelling differences in characteristics of each panel (Greene, 2008). In the textbook of econometrics on panel data analysis, the thesis finds several models on panel data in accordance with the assumptions of individual effects: fixed effects model, random effects model, generalized least squares (GLS) estimator, and autocorrelation in panel data models (Greene, 2008; Maddala, 2004). Fixed effects model is suitable when individual effect, c_i is unobserved but correlated with independent variables (Greene, 2008). The term of fixed means that there is correlation of c_i and independent variables (Greene, 2008). Random effects model takes the assumption that the unobserved individual effect can be assumed to be uncorrelated with independent variable X_{it} (Greene, 2008). Generalized least squares (GLS) estimator is suitable when each disturbance, ε_i is correlated with other disturbance, ε_j or has different variance (heteroscedasticity) (Greene, 2008).

In the literature of transport infrastructures and port, some studies use panel data models with fixed effects (Alvarez et al., 2016; Arbues et al., 2015; Bottasso et al., 2013; Bottasso et al., 2014; Cantos et al., 2005; Cheung and Yip, 2011; Park and Seo, 2016; Shan et al., 2014; Tovar and Wall, 2014). Fixed effects model is considered as a proper model for accounting for regional characteristics or port specific heterogeneity (Bottasso et al., 2014; Shan et al., 2014; Tovar and Wall, 2014). Other papers choose panel data model after evaluating efficiency and consistency of random effects model by Hausman test (Alvarez et al., 2016; Park and Seo, 2016; Shan et al., 2014).

The thesis adopts a few of tests for selection of panel data model while adopting Equation 4.2: Hausman test, test for autocorrelation in disturbance and test for heteroscedasticity in disturbance, ε_i (Greene, 2008). We first take the Hausman test in order to evaluate the efficiency of the fixed effects model and the random effects model as shown in Table 4.3. The result of Hausman test tells that unobserved individual effect is uncorrelated with independent variable X_{it}. The Hausman test shows better efficiency of the random effects model.

Table 4.3: Summary of suitability tests for models of regional panel

Test	Results
Hausman test	$\chi^2(6) = 6.8$; Prob. > χ^2: 0.34
Wooldridge test for autocorrelation in panel data	F(1, 10) = 5.5; Prob. > F = 0.03
Likelihood-ratio test of homoscedasticity	$\chi^2(10) = -61.1$; Prob. > χ^2: 1

Note: Prob. means probability.

Source: Author’s elaboration on the data of Statistics Korea (1991–2011) and Ministry of Oceans and Fisheries of Korea (2017).

Since panel data include the characteristics of time-series, the disturbance, ε_i may show the autocorrelation in the groups in the panel (Greene, 2008). The result of the Wooldridge test shows autocorrelation of panel. The heteroscedasticity violates an important assumption of classical linear regression model, homoscedasticity of disturbance (Gujarati, 2003). We cannot reject the null hypothesis of homoscedasticity in disturbance term of panel in likelihood-ratio test.

Therefore, this Chapter adopts first panel data model of random effects model and the methods of generalized least squares (GLS) estimator. After this, this Chapter will test moderating effects focused on container throughput of Busan Port and other independent variables. Finally, this Chapter checks robustness of models.

4.4 Results

4.4.1 Model description

All models depict the relationship between the dependent variable, the output of regional manufacturing and independent variables: wages, capital, intermediates, container throughput of Busan Port, export market penetration index, the cargo tonnage inside containers of Busan Port and road length. All models adopt the method of the linear regression model. Following the results of the suitability tests of models at 4.3.3 and Equation 4.2, the thesis builds first random effects model as shown in Table 4.4, Model 4.1.1, which assumes that unobserved individual effect is uncorrelated with independent variables. Since Table 4.3 shows us autocorrelation of disturbance, ε_i, the thesis develops two models of generalized least squares estimator: Model 4.1.2 without the variable of road length and Model 4.1.3 with the variable of road length as listed in Table 4.4.

Model 4.1.4 and 4.1.5 in Table 4.4 illustrate panel data models of the autocorrelation of disturbance. Model 4.1.4 includes the same independent variables of Model 4.1.3 but Model 4.1.5 uses the cargo tonnage inside containers of Busan Port in place of container throughput of Busan Port in Model 4.1.4. Model 4.1.6 of generalized least squares estimator uses the dependent and independent variables in first difference format in order to check the robustness of Model 4.1.3 and Model 4.1.4.

4.4.2 Results of panel data model

The thesis collects the raw data of all Korean manufacturing and arranges the data into the panel data of regionally aggregated by each manufacturing industry. The thesis adopts the zoning of 16 administrative regions and the manufacturing industry classification of two digits by the Statistics Korea. The thesis uses STATA (Statistics

Data Analysis) 14 program in order to calculate estimators of coefficients of independent variables as shown in Equation 4.2. The STATA gives us the outcome of linear regression methods of panel data models.

Table 4.4 illustrates panel data models and main results. All models except Model 4.1.1 show positive coefficients of container throughput or tonnage inside containers of Busan Port. The coefficient of container throughput of Busan Port is positive in Model 4.1.2 without road length. Model 4.1.3 and Model 4.1.4 with the variable of road length give us positive coefficients for the container throughput of Busan Port. Although coefficients of export market penetration index are negative, coefficients of road length are positive in these two models. The results of Model 4.1.3 and Model 4.1.4 imply that container port and road as representative transport infrastructures contribute to improving the productivity of Korean manufacturers.

Then, this Chapter checks robustness of results of panel data models. The thesis tries to confirm the robustness of positive correlation between output of manufacturing in Korea and container throughput of Busan Port by testing this positive correlation in difference variables or more stressful circumstances (Chen, 2009; Parola et al., 2013; Shan et al., 2014). Parola et al. (2013) detail a few methods of robustness check: additional independent variables; other regression model; and separation of a sample into sub-samples. First, this Chapter uses the cargo tonnage inside containers of Busan Port instead of the container throughput of Busan Port as shown in Model 4.1.5. Second, this Chapter adopts the differences of main variables of panel data models as listed in Model 4.1.6.

In Model 4.1.5, we find that the coefficient of the cargo tonnage inside containers of Busan Port is positive and the coefficients of other variables also stay on similar levels as in Model 4.1.3 and Model 4.1.4. The coefficient of export market penetration index in Model 4.1.5 is negative.

Table 4.4: Panel data models of regional panel

Item/Model	Model 4.1.1 Random Effects	Model 4.1.2 GLS	Model 4.1.3 GLS	Model 4.1.4 GLS panel AR(1)	Model 4.1.5 GLS panel AR(1)	Model 4.1.6 GLS
Wages	0.30***	0.25***	0.24***	0.27***	0.27***	0.18***
Capital	0.01***	0.04***	0.04***	0.02***	0.02***	0.01
Intermediates	0.71***	0.74***	0.75***	0.74***	0.74***	0.67***
Container throughput of Busan Port	-0.06	0.16***	0.13***	0.15***	-	0.14**
Export penetration index	0.11	–0.22***	-0.18**	–0.25***	–0.17**	0.04
road	-	-	0.03*	0.02**	0.02***	0.02***
Tonnage of container throughput of Busan Port	-	-	-	-	0.10***-	-
Sample size	330	331	330	330	330	314
R^2	0.99					
χ^2	22,789	5,538,355	5,824,165	2,116,174	2,243,708	1,386
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

Hence, Busan Port, sharing over 70% of volumes of Korean containers in the 2010s, has shown a positive effect on changes in the regional output of manufacturing industries. Since the index of export market penetration has a negative and statistically significant coefficient in all models except Model 4.1.1 and 4.1.6, we may suppose that the improvement of global competitiveness of Korean manufacturers may divert foreign direct investment of Korean manufacturers to foreign countries.

4.4.3 Moderating effects

Moderating effects means an interaction between variables (Ali et al., 2016; Yang and Park, 2014; Yuen et al., 2016). Since the thesis analyses the effects of port activity on

Korean manufacturing, we first test the moderating effects around container throughput of Busan Port in Chapter 4: moderating effects of container throughput of Busan Port on the correlation between output of Korean manufacturing and other independent variables. The thesis tests the moderating effects through a general regression method. If we find an interaction between container throughput of Busan Port and other variables, we suppose that the container throughput of Busan Port varies the productivity of other inputs. By observing this, we can assert that container ports can affect the productivity of some inputs of production for manufacturing industries.

This Chapter generates four moderators for examining the moderating effects as shown in the Table 4.5. First moderator indicates interaction between container throughput of Busan Port (bsportth) and intermediates (intm); second moderator between container throughput of Busan Port and capital (tanyield); third moderator between container throughput of Busan Port and wages (wages); and fourth moderator between container throughput of Busan Port and index of export market penetration (marketpe). We calculate four moderators after the normalization of these variables.

Table 4.5: Moderators in panel data models

Four moderators of moderating effects
Interact 1= (normalization value of bsportth * normalization value of intm)
Interact 2= normalization value of bsportth * normalization value of tanyield
Interact 3= normalization value of bsportth * normalization value of wages
Interact 4= normalization value of bsportth* normalization value of marketpe

Note: marketpe; index of export market penetration calculated by the World Bank.

The thesis adopts also the linear regression models to check the moderating effects. The models with moderating effects depict the relationship between dependent variable, output of regional manufacturing and independent variables, wages, capital, intermediates, container throughput of Busan Port, export market penetration index, the cargo tonnage inside containers of Busan Port, road length and moderator. The thesis uses generalized least squares estimator in accordance with the results of Table 4.3.

Table 4.6: Moderating effects of regional panel

Item/Model	Model 4.2.1 GLS	Model 4.2.2 GLS	Model 4.2.3 GLS	Model 4.2.4 GLS	Model 4.2.5 GLS	Model 4.2.6 GLS
Wages	0.25***	0.24***	0.24***	0.26***	0.25***	0.18***
Capital	0.04***	0.04***	0.04***	0.03***	0.04***	0.01
Intermediates	0.73***	0.75***	0.74***	0.74***	0.73***	0.64***
Container throughput of Busan Port	0.11***	0.12***	0.12***	0.10***	-	0.13**
Export penetration index	–0.14*	–0.18**	–0.16**	–0.14*	–0.08	0.05
Road	0.03***	0.03***	0.03***	0.03***	0.03***	0.003
Tonnage of container throughput of Busan Port	-	-	-		0.07***-	--
Interact 1	0.01**	-	-	-	0.01**	0.003
Interact 2	-	0.001	-	-	--	
Interact 3	-		0.01*	-	-	
Interact 4	-			0.08**		
Sample size	330	330	330	330	126	314
χ^2	5,924,876	5,824,481	5,884,174	6,042,637	7,749,683	1,391
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

Model 4.2.1 in Table 4.6 contains dependent variable, output of regional manufacturing and independent variables, wages, capital, intermediates, container throughput of Busan Port, export market penetration index, road length and a moderator between container throughput of Busan Port and intermediates. Model 4.2.1 aims at checking moderation effects of the two variables. Similarly, Model 4.2.2 includes a moderator between container throughput of Busan Port and capital input, yield of tangible assets; Model 4.2.3 with a moderator between container throughput of Busan Port and wages; and Model 4.2.4 with a moderator between container throughput of Busan Port and the export market penetration index. Model 4.2.5 and Model 4.2.6 aim at checking the robustness of the results of Model 4.2.1.

Table 4.6 demonstrates that the coefficient of moderating effects between container throughput of Busan Port and intermediates is statistically significant in Model 4.2.1. Model 4.2.3 illustrates the positive moderating effects between container throughput of Busan Port and wages as a proxy for labour input. Hence, we can surmise from the results of these models that the activity of Busan container port promotes positive effects of intermediates and labour inputs on the output of Korean manufacturers and that the development of Busan Port positively affects productivity of intermediates and labour inputs.

The positive coefficient in moderator between container throughput of Busan Port and intermediates implies that the development of Busan Port would encourage good quality of intermediates to be imported easily into Korea. Korean manufacturers may take benefits by importing advanced materials from foreign countries. A good example of this is the frequent liner services between Korea and Japan, which since the late 1980s helped Korean manufacturers to build international division of production between two countries as shown in the case of automobile industry (Guerrero and Itoh, 2017). The moderating effect between container throughput of Busan Port and index of export market penetration is positive in Model 4.2.4. This implies that Busan container port positively affects the global competitiveness of Korean manufacturers. Hence, we can notice further that the development of Busan Port not only lowers the transport costs but also positively affects the productivity of intermediates and labour inputs.

4.4.4 Robustness check

The thesis evaluates the robustness of positive correlation between container throughput of Busan Port and other independent variables. This Chapter checks the robustness of the moderating effects by using the cargo tonnage inside containers of Busan Port, instead of the container throughput of Busan Port as shown in Model 4.2.5 of Table 4.6, and adopting the differences of the main variables of panel data models, as listed in Model 4.2.6 of Table 4.6. We find that the coefficient of the first moderator in Model 4.2.5 is positive and the coefficients of other variables stay in a similar level as in Model 4.2.1. However, Model 4.2.6 fails in showing the positive coefficient of the first moderator. Consequently, the findings in the robustness check are similar to Goss's (1990) assertion of the specialization and diversification of regional economy with an efficient port, which might be achieved by both lower transport costs and the improvement of productivity of production inputs as shown in Table 4.6.

4.5 Discussions

This Section explores the question of whether the regional effect of container ports can vary in accordance with temporal changes and different regions. Another important question is whether transshipment activity of a container port can contribute to regional manufacturing industries.

4.5.1 Analysis by period

The panel data models in Table 4.4 and 4.6 illustrate a positive regional effect of container ports, specifically Busan Port, on manufacturing industries in Korea. This Chapter divides the examined period into two periods on the basis of the transshipment ratio of Busan Port and the starting year of the crisis in the foreign exchange market of Korea: the first period from 1991 to 1998 and the second period from 1999 to 2011. We find a difference between the coefficients of two different periods.

Models in the analysis by period also use the methods of linear regression and generalized least squares estimator in accordance with the results of Table 4.3. Model 4.3.1 in Table 4.7 examines the effects of independent variables on the dependent variable, output of regional manufacturing during the period 1991-1998 and Model 4.3.2, the period 1999-2011.

Model 4.3.1 in Table 4.7 including the first period demonstrates the positive coefficients of the container throughput of Busan Port and road length. Busan Port did have a positive economic effect on the output of Korean manufacturing industries in the first period. Nevertheless, the effect of container throughput of Busan Port on the outputs of Korean manufacturing is inconclusive in the second period, as shown in Model 4.3.2 even with the positive coefficient of road length. Since the ratio of transshipment containers in container throughput of Busan Port reached 41% in 2002 from under 20% in the 1990s, the connection between container throughput of Busan Port and the regional outputs of Korean manufacturing seems to be weakened from the early 2000s.

Table 4.7: Panel data models by period and region

Item /model	Model 4.3.1 GLS 1991-1998	Model 4.3.2 GLS 1999-2011	Model 4.3.3 GLS BS,IN 1991 -2011	Model 4.3.4	Model 4.3.5	Model 4.3.6	Model 4.3.7
				GLS, Other region			
				1991 -2011	1991-1998	1999 -2011	1991 -2011
Wages	0.26***	0.25***	0.33***	0.25***	0.27***	0.25***	0.26***
Capital	0.13***	0.04***	0.01	0.04***	0.12***	0.03***	0.04***
Intermediates	0.61***	0.75***	0.77***	0.74***	0.61***	0.75***	0.73***
Container throughput of Busan Port	0.15***	0.01	-0.18**	0.15***	0.15***	0.03	
Export penetration index	-0.16	0.18	0.21*	–0.22***	–0.15	0.13	-0.11*
Road	0.05***	0.02**	0.06	0.02**	0.04***	0.01	0.02**
Tonnage of cargoes inside containers	-	-	-	-		-	0.09***
Interact 1							0.01**
Sample size	122	208	42	288	106	182	288
χ^2	2367007	4189635	6164620	5027607	1872657	3704399	5127999
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

4.5.2 Analysis by region

Models in the analysis by region adopt the methods of linear regression and generalized least squares estimator in accordance with the results of Table 4.3. Model 4.3.3 in Table 4.7 examines the effects of independent variables on the dependent variable, output of regional manufacturing in the regions of a big port, Busan (BS) and Incheon (IN). Model 4.3.4, Model 4.3.5, and Model 4.3.6 analyse the effects of independent variables on the dependent variable in other regions in Korea except Busan and Incheon; Model 4.3.4 during the examined period 1991-2011, Model 4.3.5 during the period 1991-1998, Model 4.3.6 during the period 1999-2011. Model 4.3.7 adopts cargo tonnage inside containers of Busan Port in place of container throughput of Busan Port in order to check robustness of the results of Model 4.3.4.

The first regions with a big port in Model 4.3.3 show that the regional effect of container ports is negative. This seems to be caused by the industrial changes caused by the continually increasing inflow and outflow of goods through the big port in the region. The increase of container throughput of Busan Port may promote the growth of service industries such as wholesalers rather than manufacturers.

On the contrary, Model 4.3.4 shows that container throughout of Busan Port affects positively the output of regional manufacturing industries in the other regions without a big port. The regions without a big port have the benefits of improved accessibility to global markets in accordance with the development of Korean container ports. When dividing the examined periods again into the two periods from 1991 to 1998 and from 1999 to 2011, we find that the positive coefficients of the container throughput of Busan Port and road in the other regions in the first period as shown in Model 4.3.5. However, the effects of container throughput of Busan Port and road in the second period in Model 4.3.6 are inconclusive for the other regions.

This Chapter checks the robustness of the moderating effects between container throughput of Busan Port and intermediates in the other regions without a big port by using the tonnage inside containers of Busan Port instead of container throughput of Busan Port. We find that the coefficient of the sign of moderator in Model 4.3.7 is positive and the coefficients of other variables in Model 4.3.7 stay in similar levels as in Model 4.3.4 in Table 4.6.

4.5.3 Analysis on the relationship between transshipment and manufacturing industries

Since a hub port tends to handle a larger portion of transshipment from foreign countries, it is important to examine the effects of transshipment activity by container ports on the output of the manufacturing industries in Korea. If we find a positive effect of transshipment activity, it implies that a high ratio of transshipment in a port can improve the output production of its regional manufacturing industries.

Models in Table 4.8 use the methods of linear regression and generalized least squares estimator in accordance with the results of Table 4.3. Models are composed of the dependent variable, output of regional manufacturing and independent variables: wages, capital input, transshipment container throughput of Busan Port or transshipment container throughput of regional ports, export market penetration index, and road length. Model 4.4.1 adopting transshipment activity of Busan Port takes a log linear regression model with generalized least squares estimator. In Model 4.4.2 adopting transshipment activity of Busan Port, the variables are in the format of differences of logarithms of variables. While inputting transshipment activity of regional port in Korea, Model 4.4.3 checks the effects of regional port transshipment. Model 4.4.4 checks the effects of transshipment activity of Busan Port on manufacturing in the regions of Busan and Incheon; Model 4.4.5 checks the effects in other regions.

In the panel data models of Model 4.4.1, 4.4.2 and 4.4.3 as shown in Table 4.8, we find inconclusive effects of transshipment movement of Busan Port and transshipment movement of Korean container ports. When dividing the 16 regions into two regions: the port cities, Busan and Incheon, and other regions, we find inconclusive effects of transshipment activity of a container port on manufacturing industries in Model 4.4.5 of other regions without a big port. Although Model 4.4.4 illustrates a negative coefficient of transshipment activity of Busan Port in the port cities, Busan and Incheon, it fails in giving a significant coefficient of wage.

Table 4.8: Panel data models of transshipment movements

Variables /model	Model 4.4.1 GLS 1991-2011	Model 4.4.2 GLS 1991-2011 Differences	Model 4.4.3 GLS 1991-2011 Differences	Model 4.4.4 GLS, BS & IN	Model 4.4.5 1991-2011, Other regions
Intercept	0.54	0.003	0.0004	2.38	0.68
Wages	0.24***	0.20***	0.11	0.07	0.25***
Capital	0.03***	0.004	-0.01**	0.01*	0.03***
Intermediates	0.75***	0.65***	0.77***	0.79***	0.75***
Transshipment container of Busan Port	-0.003	0.01	-	-0.05**	0.001
Transshipment container of Korean regional ports	-	-	-0.02	-	-
Export penetration index	0. 03	0.13	0.06	0.55***	0.01
Road	0.03***	0.22	0.22	-0.14***	0.01**
Sample size	330	314	43	42	288
χ^2	110715	995	379	13906	10872
Probability > χ^2	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

We find here that transshipment activity at Busan Port and Korean container ports does not affect overall the output of Korean manufacturing industries in the port cities and other regions. Hence, with a higher ratio of transshipment in a port, an economic separation between a port and its regional economy in particular manufacturing industries may occur.

4.6 Conclusions

In order to explore the basic questions of this Chapter, we collect panel data of Korean manufacturing industries and port activities. Then this Chapter examines the relationship between container throughput of Busan Port and output of Korean manufacturing industries.

This Chapter observes that the regional effects of Busan Port on manufacturing industries in Korea are positive. Even after adding the length of road as an indicator of other transport infrastructures, we get the positive coefficients of container throughput of Busan Port and road length. These results are confirmed in the robustness check where we replace the container throughput of Busan Port with the cargo tonnage inside containers of Busan Port.

This Chapter finds positive moderating effects between the container throughput of Busan Port and intermediates, and between the container throughput of Busan Port and wages. We can ascertain from the results that the activity of Busan container port enhances the productivity of intermediates and labour inputs in Korean manufacturers in the models.

This Chapter notices that the regional effects of container ports vary in accordance with temporal change and by region. In the case of Korea, the first period from 1991 to 1998 demonstrates the positive coefficients of the container throughput of Busan Port and road length. Nevertheless, the effect of container throughput of Busan Port on the outputs of Korean manufacturing is inconclusive in the second period.

When dividing the examined regions into two regions, we observe that the regions with a big port, Busan and Incheon, show that the regional effect of container ports is negative. However, the container throughput of Busan Port affects positively the output of regional manufacturing industries in other regions. The regions without a big port have benefits of improved accessibility to global markets in accordance with the development of Korean container ports.

In this Chapter we also find that transshipment activity of Korean container ports does not have an overall effect on the output of Korean manufacturing industries in the port cities and other regions. Hence, the economic interaction between a container port and its regional economy might be lowered in accordance with the growth of transshipment movement in container throughput of Korean container ports.

These findings will be discussed further when looking at specific manufacturing industries with panel data of each firm or each business unit, in the next two chapters. Chapter 5 reviews the effects of container ports on the leather, bag and shoe industry in Korea.

5. Spatial Effects of a Container Port on the Output of the Leather, Bag and Shoe Industry in Korea

5.1 Introduction

The previous Chapters reviewed overall the role of container ports in the development of maritime industry and manufacturing industries. At Chapter 4 we find that first, Busan Port as a hub port rather than a Korean regional port affects positively the aggregated output of enduring manufacturing establishments. Second, the coefficients of container throughput of Busan Port have varied in the second period when we divide the examined period into the two periods. Third, the economic ties between a container port and its regional economy might be loosened in accordance with the growth of transshipment movement of the container port.

Chapter 5 focuses on the economic effects of container ports on a specific manufacturing industry, the leather, bag and shoe industry. Since Chapter 4 uses the aggregated panel data of all manufacturing industries, the results of Chapter 4 might be different to the results in a specific industry. Furthermore, a possible example of this could be the leather, bag and shoe industry located mainly around Busan Port until the early 1990s. Hence, Chapter 5 shows us whether and how the industry in a proximate distance to Busan Port was affected.

Transport is the indisputable connector between production and supply activities. From the vantage point of industry and business, the location of a production plant and a business entity determines the extent to which they can realise profits and reduce costs. Scholars have verified that cheaper or better goods, materials, and intermediates for consumption and production can be found in an open and networking economy than in a closed and land-locked one (Gallup et al., 1999; MacKellar et al., 2000; Rodrigue and Notteboom, 2010a).

In Korea, ports are the key transport infrastructures, handling nearly 100% (99.6%) of foreign trade by volume (Ministry of Land, Transport and Maritime Affairs of Korea, 2009b). The thesis selects the leather, bag and shoe industry since its shares of output in manufacturing in Busan declined dramatically from 22% in 1991, top-rank in manufacturing industries in Busan to 5.6% in 2011 (Statistics Korea, 1991–2011). In the late 1910s, at the outset of the shoe industry, Busan Port introduced new technologies and raw materials from foreign countries, and continued to promote the industry’s growth beyond the 1960s (Jeong, 2004; Shin, 2004; Kim et al., 2008). By the late 1980s, however, a number of Korean labour-intensive manufacturers of leather, bags and shoes relocated their plants to other countries where labour costs were lower (Shin, 2004; Seo et al., 2015). Leather, bag and shoe production in Korea decreased its shares of employment, output, and value added in manufacturing industries, from 3.5%, 2%, and 2.2% in 1991 to 1.2%, 1.2%, and 0.9% in 2011 respectively (Statistics Korea, 1991–2011). The industry also witnessed a dynamic reversal in trade: from exporter in the 1990s to importer in 2003.

When deciding on investments for transport infrastructure, like ports or container terminals, the Korean government evaluates the regional effects of such development mainly through the use of Input-Output Table, such as in the standard guidelines for pre-feasibility studies on ports (Kim, 2001) and general guidelines for pre-feasibility studies (Shim, 2004). The Input-Output Tabl interprets the expansion and development of a port facility as an external additional input of industries. The model always yields positive production inducement effects, value added effects, and employment inducement effects, as illustrated in a Korean case (Kwak et al., 2005). As a result, policy makers only observe the combined positive results but not the concrete impacts of the port development on each industry. In the literature on a port and regional economy, we notice that individual industries are analysed in exceptional cases. Using robust methods to evaluate actual regional effects of transport infrastructure development is important in the design of regional and port development policy. Furthermore, when an industry supplies major employment and production in a regional economy as in the case of the leather, bag and shoe industry in Busan in the early 1990s, a more precise evaluation of port development can provide policy improvements. In our view, it is therefore useful to test the regional and spatial effects for a specific industry over long-term periods.

The present Chapter aims to evaluate the effects of container port activities on the output of leather, bag and shoe manufacturing, which has been in decline since the late 1980s. For this purpose, we gather three types of panel data on the industry surveyed by the Statistics Korea: the *regional* panel data on the industry, panel data on *enduring establishments* that sustained their business activity from 1991 to 2011, and panel data on *industrial complexes*. Container throughput is introduced as an indicator of port activity from 1991 to 2011. Due to inconsistent data and insufficient case numbers in the panel data of industrial complexes, we apply a panel data model on the regional data and the data of enduring establishments. We also examine whether generally positive effects of port development can be confirmed in the industry and discuss how regional impacts of a port occur in regions over different periods.

Our contribution to the literature has three sides. First, this Chapter reviews the regional effects of container ports on a specific manufacturing industry, which shows a decrease in comparative competitiveness in global trade. Controlling the changes of comparative competitiveness of Korean manufacturing, this Chapter tries to examine precisely the effects of port development on a specific manufacturing sector. Second, the thesis evaluates the effects not by aggregated and averaged variables, but by the variables of each establishment of the manufacturing group. By using panel datasets of each business unit, this Chapter traces the effects of port development on the specific manufacturing sector. Third, while more studies may need to be done, the thesis points to trends in the specialization and the international division of production in accordance with transport development, which are asserted in the literature of economic geography. A microeconomic investigation of this Chapter in longitudinal and cross-sectional cases provides a hint on the phenomena of the specialization and the international division of production.

This Chapter is set out as follows. Section 2 reviews the literature on the relationship between ports and their regional economies. Section 3 describes the data and modelling. Data are composed of the statistics of regional output and input of leather, bag and shoe manufacturing. We examine the stationarity of panel data through a unit root test. In Section 4 we provide the results of our panel data model using two types of data: regional and enduring establishment data of the industry. Section 5 includes three subjects: analysis by region, examination of the relationship between transshipment activity and the output of leather, bag and shoe industry, and panel data models and their results of enduring establishments. Lastly, Section 6 discusses the policy implication of the results in views of the stakeholders in Korean container ports. The section also reiterates our findings and suggests the next steps for research in this area.

5.2 Literature review

A port has three main relationships with its hinterlands and the regional economies: transport networking, spatial interaction, and economic ties. Insofar as the effects of a port on regional economies and hinterlands are concerned, we find in relation to port development that the function of a port has evolved from a simple node to a phase of regionalisation (Notteboom and Rodrigue, 2005). Regionalisation of a port suggests the formation of transport networks between a port and its hinterlands. In addition, in spite of analyses on the spatial structure between a city and its port in Africa, Europe and Asia by Gleave (1997), Ducruet and Jeong (2005), and Lee et al.(2008), we still must ask questions on how, why, and to what degree a port specifically affects each industry and each business unit.

Therefore, the thesis intends to magnify the analysis in order to understand precisely the relationship between port development and its effect on specific industries. Papers on transport development generally emphasise the positive impacts of transport facilities in aggregated terms that can lower transport costs and improve accessibility (Gallup et al., 1999; Limao and Venables, 2001; Harringan and Venables, 2006; Behrens et al., 2009; Jiwittanakulpaisarn et al., 2010; Li and Li, 2013; Tong et al., 2013; Park and Seo, 2016). According to some of the economic geography literature, lower transport costs influence the production decisions of a firm as well as the spatial division of production (Krugman, 1980; Beckmann and Thisse, 1986; Behrens and Picard, 2011). Behrens and Picard (2011) assert that trade imbalances introduce asymmetric freight rates between inbound cargo and outbound cargo, and manufacturing firms may disperse economic activities from a larger country or market to a smaller country or market. Nevertheless, the literature on economic geography seldom investigates a firm's production decision when the transport network in a region changes.

Flows of outputs and inputs through transport network seem to improve productivity of specific industries and firms, similarly to the case studies of trade liberalization and reallocation of output and input by Pavcnik (2002) and Foster et al. (2001). Although Goss (1990) does not study in detail the effects of port development on specific manufacturers, he does suggest that the improvement of port efficiency can benefit both producer and consumer; he goes on to specialization in some sectors and diversification in others (Goss, 1990). One study interpreting the role of a port in containerisation in the USA finds that ports may cause the economic decline in the port district (Grobar, 2008). As the global economy and regional industries evolve, some industries grow as others diminish and we can observe how port cities shift their manufacturing from developed to developing countries, and how, gradually, industrial clusters start to change and sometimes disappear.

Stevens et al. (1981) examine the regional effects of port development and point the positive inducement effects in Massachusetts in the US. Cohen and Monaco (2008) conclude that port infrastructure contributes to the regional output of manufacturing in the US. In recent studies we can see different attempts to assess the regional effects of port development. For example, while using regional and macro panel data of China from 2003 to 2010, Shan et al. (2014) find positive effects of a port (or container port) on the economic growth of Chinese regions. In the analysis on aggregated regional production function of Spain, Arbues et al. (2015) illustrate that only road development brings positive effects to regional production while the other transport modes do not show a clear impact on the regional economy. Park and Seo (2016) aggregate the impact of seaports on the regional economies in Korea, adopting regional GDP including fishery and agriculture, manufacturing, and service activities. These papers use an aggregated concept of economic growth, which, however, prevents them from investigating specific impacts of a port on each manufacturing industry, each establishment, and over different periods. Although Bottasso et al. (2013, 2014) analyse the spillover effects of port throughput on the regional growth of a port city and other regions, they also neglect to test the impacts of a port at the industry and establishment levels. These aggregated approaches that almost always produce optimistic results are limited because they do not explain why a major port exists in the face of a shrinking city, along with the demise of specific manufacturing industries in that city and its hinterlands.

In general, manufacturing industries evolve through different stages: emergence, growth, competition, and decline, similarly as in the vision of creative destruction by Schumpeter (Krafft et al., 2014). We suggest that insights can be gained from studying the effects of a port on specific industries in different stages of their evolution and comparative competitiveness in global trade. For example, the leather, bag and shoe industry in Korea began moving its main plants to developing countries in the late 1980s (e.g., Thailand and Indonesia), and closing some factories because competition was severe. However, the port of Busan developed into a hub port in the 1990s, largely due to an increase in transshipment containers from neighbouring countries, especially Japan and China (Chang, 2000). The Korean government, municipal governments, and port authorities in Korea tend to believe that port development brings positive effects to the regional economies. Therefore, they have tried to build larger port terminals and logistics facilities nearby ports in order to attract cargo from manufacturers and promote diverse industrial activities (Seo et al., 2015).

5.3 Modelling

5.3.1 Panel data models

Although the Input-Output model shows rigid and positive effects of ports, it is used widely to verify the positive effects of port development on other industries (Kwak et al., 2005). In general, port development has, on average, positive results; however, the reffect of a specific industry in a region may yield different outcomes. Starting from the vantage point that, in an open economy, transportation matters at decision level on the location of production and with regard to patterns of trade, Krugman (1980) and Behrens and Picard (2011) developed models in which a more even spatial distribution of firms and production occurs when freight rates are considered as endogenous. Krugman (1980) mainly considers market size and transportation costs for each country, and agglomeration in the region where economies of scale are better, whereas Behrens and Picard (2011) focus on the difference in transportation costs in accordance with trade direction, and the possibility of agglomeration in the smaller country due to lower transportation costs to export. In container transport and hub-and-spoke networks, a hub port in particular tends to build diverse and high frequency feeder networks with regional small and medium sized ports. Hence, it is controversial how development of a hub port affects a specific regional industry.

As a transport infrastructure, a container port may shift production function (Bottasso et al., 2014; Shan et al., 2014). Production function as illustrated in Equation 5.1 includes the value of output of, e.g., leather, bag and shoe manufacturing establishments, and inputs: labour, capital, intermediates, and port activity indicators including such as port throughput or the handling capacity of a port.

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$$Y = F(L, K, IM, pt) \tag{5.1}$$

Where,

Y: regional output of leather, bag and shoes,

L: labour input,

K: capital input,

IM: input of intermediates,

pt: container throughput of a port.

Firms in an open economy are exposed to competition from foreign competitors. A firm can also move its plants to foreign countries. Therefore, from the point of view of a country, its position in manufacturing and global trade can shift from production to consumption. The trade specialization index (TSI) ranging from +1 to –1 specifies the position of export and import for manufacturers in a country (UNCTAD, 2013). Hence, we can trace the positioning of the Korean leather, bag and shoe industry by calculating the TSI. Another indicator, revealed comparative advantage (RCA) varying over 0, informs us on the comparative competitiveness of each manufacturer for a country involved in global trade. We add the RCA index of the industry as an independent variable in the production function to evaluate the comparative competitiveness of the industry in the world. The production function can now be rewritten as in Equation 5.2.

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$$Y = F(L, K, IM, pt, rca) \qquad (5.2)$$

Where,

rca: revealed comparative advantage.

Regional output, as shown in Table 5.1, represents the output value of leather, bag and shoe manufacturing for the 16 administrative regions in Korea, listed in Figure 1.4. We use wages as a proxy for labour input. Value of capital input is calculated by multiplying the tangible assets and the yield of private bonds. Intermediates are composed of raw materials, fuel, electricity, and other materials for production. In Table 5.1 port throughput indicates the container movement around the regional port where leather, bag and shoe manufacturers are located. Table 5.2 illustrates correlation coefficients between main variables. Container throughput of Korean container ports shows weak correlation coefficients with output of the leather, bag and shoe industry in Korea.

Total output and employees of the industry are shown in Figure 5.1. We can observe that total output of the industry drops from 6.1 trillion Korean won in 1991 to 4.6 trillion Korean won in 2011. We also observe in the figure that total employees plummet from 160,000 to 17,000. This sharp decrease occurs mainly in the Busan region, which had attracted shoe manufacturers since the 1960s. The output and employees of the industry in Busan fall from 2.8 trillion Korean won and 100,000 employees in 1991 to 1.0 trillion Korean won and 6,200 employees in 2011.

Table 5.1: Summary of panel data in regional level

Item	Min	Max	Mean	Standard deviation
Output (million Korean won)	0	2,839,696	265,614	513,984
Wages (million Korean won)	0	624,375	32,693	70,003
Intermediates (million Korean won)	0	1,316,339	133,635	273,427
Tangible assets (million Korean won)	0	621,583	58,011	115,024
Container throughput (Thousand TEU)	0	15,523	625	2,115

Note: Some regions show non-existence of the industry.
Source: Author's elaboration on the data of Statistics Korea (1991-2011) and Ministry of Oceans and Fisheries of Korea (2017).

Table 5.2: Correlation coefficients between main variables

Variable	output	portth	mportth	wages	intm	tanyield	emp
output	-	0.322	0.323	0.924	0.986	0.887	0.760
portth	0.322	-	0.999	0.420	0.302	0.218	0.329
mportth	0.322	0.999	-	0.420	0.302	0.217	0.328

Note: portth: container throughput of container ports; mportth; moving average of portth; intm: costs of intermediates; tanyield; yield of tangible assets; emp: employment.
Source: Author's elaboration on the data of Statistics Korea (1991-2011).

As a labour-intensive industry, leather, bag and shoe manufacturing was a main exporter in Korea during the 1970s. However, global demand for these products soon began spiralling downward; at the same time, other foreign producers in Asia were vigorously competitive during the 1980s. In Figure 5.2 the TSI of the industry of Korea indicates a change from an exporting to importing country around 2003, recording negative numbers for the first time: from 0.06 in 2002 to –0.04 in 2003. Since 2002, the TSI depicts a steady downward slide in the industry's international competition. The RCA index also records continuous decrease in the competitiveness of manufacturing in world trade, falling from 16.25 in 1991 to 0.11 in 2011.

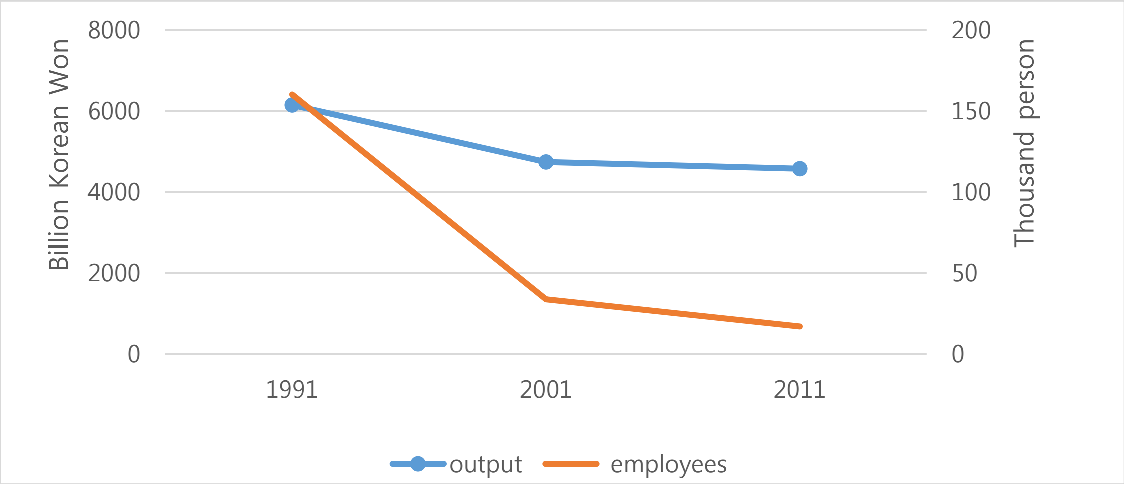

Figure 5.1: Trend of output and employees of leather, bag and shoe industry
Source: Author's elaboration on the data of Statistics Korea (1991-2011).

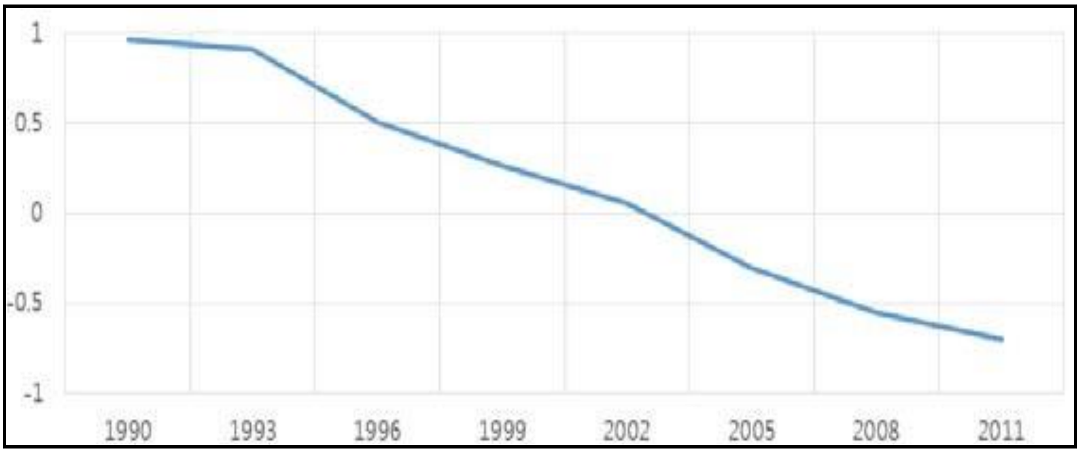

Figure 5.2: TSI trend of the manufacturing for leather, bag and shoe
Note: TSI is calculated by weighted average of two industries in HS code of 42 (leather or of animal gut, harness, travel goods, handbags) and 64 (footwear, headgear, umbrella, walking sticks, whips, riding crops).
Source: Author's elaboration on the data of UN Comtrade (1991–2011) and Korea International Trade Association (1990–2011)

The second dataset of *enduring establishments* in the industry gives us detailed statistics of each same business unit from 1991 to 2011. Though these establishments also show continual decrease in employment, 33 establishments could sustain their production during the period.

We find that the data on port development, mainly container throughput, are collected in twenty-foot equivalent unit (TEU). We also assume that the impact of port expansion and change of competitive positioning of the industry occurs gradually. Hence, we use *moving averages* of container throughput and RCA in t year and $t-1$ year as shown in Equation 5.3 and Equation 5.4, following a similar method of the World Economic Forum (2010a).

$$mpt = 0.6pt_t + 0.4pt_{t-1} \tag{5.3}$$

$$mrca = 0.6\ rca_t + 0.4\ rca_{t-1} \tag{5.4}$$

We test the stationarity of panel data of 16 regions through Levin-Lin-Chu unit-root test (LLC) and Fisher-type unit-root test based on augmented Dickey-Fuller tests (Fisher-ADF). Since at the level data we find unit root in port throughput and RCA, as shown in Table 5.3, we adopt the difference formation of each variable in a panel regression.

Table 5.3: Panel unit root test of main variables of the leather, bag and shoe industry

Variable/Item	ρ value			
	Levels		Differences	
	LLC	Fisher-ADF	LLC	Fisher-ADF
Output	0.0002	0.000	0.254	0.000
Wages	0.002	0.000	0.002	0.000
Capital	0.000	0.000	0.000	0.000
Intermediates	0.000	0.002	0.001	0.000
Container throughput	1.000	1.000	0.999	0.000
Revealed comparative advantage	1.000	0.000	0.000	0.000

Note: ρ value at LLC indicates the value of adjusted t*; ρ value at Fisher-ADF represents the value of inverse chi-squared.

Hence, we use mainly the data of *difference formation* in empirical models as shown in Equation 5.5.

$$Y = a1 + a2\ L + a3\ K + a4\ IM + a5\ MPT + a6\ MRCA + \varepsilon \qquad (5.5)$$

Y, L, K, IM, MPT, and *MRCA* represent differences of variables of output, labour input, capital input, intermediates, moving average of container throughput, and moving average of RCA in t year. Equation 5.5 includes disturbance term ε.

The panel data include the data from 1991 to 2011, and we divide this long period into two: the first from 1991 to 2002, and the second from 2003 to 2011. Lastly, to sum up this section, we can indeed confirm from Figure 5.2, that around year 2003 the TSI of the industry shifts from positive to negative. For complementing the panel data model, the thesis adds the main result of a spatial econometric model in the next section.

5.3.2 Suitability of models

The thesis collects the panel data of leather, bag and shoe industry in Korea from 1991 to 2011. Hence, the thesis adopts a panel data model among linear regression models as shown in Equation 5.5. The thesis reviews the basic assumptions of classical linear regression model and the characteristics of individual effects in panel data models as shown in the 4.3.3 of the previous Chapter 4. In this Chapter, the thesis finds the proper models for the panel data of leather, bag and shoe industry through the similar tests of model suitability in Chapter 4. First, the thesis tests heterogeneity or individual effect in disturbance by Hausman test. Second, since the panel data of leather, bag and shoe industry in Korea from 1991 to 2011 has a characteristic of time series, the disturbance may show autocorrelation. The thesis tests the autocorrelation through Wooldridge test. Third, the thesis tests homoscedasticity of disturbance.

Hausman test shows us the efficiency of estimators of random effects model in comparison with fixed effects model as shown in Table 5.4. Although the statistics on autocorrelation do not reject the null hypothesis of no autocorrelation, the thesis finds the heteroscedasticity of the disturbance. Main results are shown in Table 5.4. These results suggest that although random effects model has efficiency in estimators, generalized least squares (GLS) estimators are more efficient than estimators of the random effects model.

Table 5.4: Summary of suitability tests for models

Test	Results
Hausman Test	$\chi^2(4) = 3.21$; Prob. > χ^2: 0.52
Wooldridge test of autocorrelation in panel data	$F(1, 4) = 1.1$; Prob. > F = 0.309
Likelihood-ratio test of homoscedasticity	$\chi^2(15) = 30{,}913$; Prob. > χ^2: 0.000

Note: Prob. means probability.
Source*:* Statistics Korea (1991–2011), Ministry of Oceans and Fisheries of Korea (1991–2011) and Author's elaboration

The thesis mainly adopts random effects model and panel GLS estimators. In the models of panel data we select various models of different types: GLS estimator and GLS estimator in heteroscedastic disturbance term with cross-sectional correlation (GLS panel corr).

5.4 Panel data models and results

5.4.1 Model description

All models in this Chapter include dependent variable, output of leather, bag and shoe industry in Korea and independent variables, wages, capital, intermediates, container throughput of container ports, revealed comparative advantage of the industry, cargo tonnage inside containers of container ports and road length from 1991 to 2011. All models adopt the method of linear regression model while taking the format of Equation 5.5. Following the results of suitability tests of models in Table 5.4, the thesis builds first random effects model, Model 5.1.1 as shown in Table 5.5. Since Table 5.4 does not show autocorrelation of disturbance, the thesis develops models of generalized least squares (GLS) estimator, Model 5.1.2 and of GLS estimator in heteroscedastic disturbance term with cross-sectional correlation (GLS panel corr), Model 5.1.3 - 5.1.8 (Table 5.5).

While Model 5.1.1 - 5.1.5 in Table 5.5 are using container throughput of container ports as an indicator of port development, Model 5.1.6, Model 5.1.7, and Model 5.1.8 are including cargo tonnage of container throughput of container ports. When considering the trend of RCA as an indicator of global competitiveness of the industry, the thesis divides the examined period into two different period: the first period when the sign of RCA is positive and the second of negative sign. Model 5.1.1, Model 5.1.2, Model 5.1.3 and 5.1.6 include the data of dependent and independent variables in difference format of the whole period 1992-2011. Model 5.1.4 and 5.1.7 use the data in difference format of the period 1992-2002; Model 5.1.5 and 5.1.8 with the data in difference format of the period 2003-2011.

5.4.2 Models and main results

In the analysis of the case of leather, bag and shoe industry in Korea the thesis calculates estimators of coefficients of independent variables as shown in Equation 5.5 through STATA (Statistics Data Analysis) 14 program. The thesis collects the raw data of Korean manufacturing by the Statistics Korea and checks missing values and the format of panel data. The STATA shows us the outcome of linear regression methods of panel data models.

Table 5.5 gives the results of panel data models with regional panel datasets of difference formation. Model 5.1.1 of random effects model and Model 5.1.2 of GLS estimator present inconclusive effects of container throughput on production of the industry from 1992 to 2011.

Table 5.5: Panel data model results at the regional panel

Item/Model	M 5.1.1 Random effects	M 5.1.2 GLS	GLS Panel corr					
			M 5.1.3	M 5.1.4	M 5.1.5	M 5.1.6	M 5.1.7	M 5.1.8
Period	1992-2011		1992-2011	1992-2002	2003-2011	1992-2011	1992-2002	2003-2011
Intercept	3958	3958	1797	2342	3435	1711	2983	2815
Wages	2.73*** (9.70)	2.73*** (9.81)	2.66*** (28.7)	2.37*** (18.8)	3.14*** (28.7)	2.66*** (25.3)	2.34*** (20.3)	3.29*** (33.0)
Capital	0.13 (0.16)	0.13 (0.16)	0.10 (0.46)	0.25 (0.89)	7.26*** (7.81)	0.17 (0.67)	0.22 (0.90)	7.48*** (8.27)
Intermediates	1.37*** (22.83)	1.37*** (23.09)	1.35*** (89.4)	1.05*** (55.2)	1.18*** (50.7)	1.35*** (78.7)	1.05*** (60.5)	1.16*** (55.5)
Container throughput	8.98 (0.69)	8.98 (0.70)	4.96*** (3.58)	-8.03* (-1.78)	8.53*** (2.80)	-	-	-
Revealed comparative advantage	-591 (-0.28)	-591 (-0.29)	-874*** (-3.33)	832*** (3.54)	-54613** (-2.27)	-1092** (-2.54)	1019*** (3.31)	-56948*** (-2.70)
Road	-8.54 (-1.29)	-8.54 (-1.30)	-6.85*** (-19.6)	-4.12*** (-4.43)	-9.30*** (-7.56)	-6.47*** (16.6)	-4.00*** (-3.27)	-8.28*** (-7.58)
Cargo tonnage	-					0.16*** (3.06)	-0.76*** (-2.97))	1.01*** (9.19)
Sample Size	304	304	304	160	144	304	304	304
χ^2 Probability>χ^2	2011 0.000	2058 0.000	31330 0.000	12327 0.000	14631 0.000	20116 0.000	13941 0.000	20332 0.000

Note: * significant at 10% level; ** significant at 5% percent level; *** significant at 1% level. The figures in parenthesis mean t value at fixed effects models and z value at random effects model.

Source: Statistics Korea (1991–2011) and author's elaboration based on the data

Model 5.1.3 in Table 5.5, showing GLS estimators in heteroscedastic disturbance term with cross-sectional correlation demonstrates positive effects of container throughput on output of the industry. After dividing the examined period into two, we obtain a contradicting result of signs in the effects of container throughput. Model 5.1.4, during the period from 1992 to 2002, indicates negative coefficient of container throughput on production; and Model 5.1.5, positive coefficient from 2003 to 2011.

The TSI shows continual decrease during the first period, signalling the positioning change in trade from production to consumption and from export to import in the global economy. In the second period, TSI confirms that the ratio of imports from foreign countries in the leather, bag and shoe industry grows incessantly. The negative effect of container throughput on production in Model 5.1.4 implies a breakdown of the existing industry cluster. The spatial econometric model also confirms a negative effect of port throughput on production from 1992 to 2002 as shown in Table 5.6, which presents direct and total effects.

Table 5.6: Direct and indirect effects of independent variables in spatial econometric model

Item/Variables	Wages	Capital	Intermediates	Port throughput	Revealed comparative advantage
Direct effect	2.36***	1.40**	0.86***	-134.6***	3.5e-10***
Indirect effect	-0.07	-0.04	-0.03	4.3	-1.34e-10
Total	2.3***	1.36**	0.84***	-130.3***	2.2e-10***

Source: Author's elaboration based on the data of Statistics Korea (1991-2011).

5.4.3 Robustness check

The thesis evaluates the acceptability of positive correlation between output of leather, bag and shoe manufacturing in Korea and container throughput of a container port in Korea by testing this positive correlation in different variables or more stressful circumstances. This Chapter checks the robustness of the main results of panel data models of Model 5.1.3, Model 5.1.4, and Model 5.1.5 through using the cargo tonnage inside containers instead of container throughput of a container port as shown in Model 5.1.6, Model 5.1.7, and Model 5.1.8 in Table 5.5. We find that the coefficients of the cargo tonnage are positive during the whole examined period from 1992 to 2011 in Model 5.1.6 but negative in the first period from 1992 to 2002 in Model 5.1.7. Model 5.1.8 shows us a positive coefficient of the cargo tonnage similar to the sign of Model 5.1.5, which demonstrates the positive effects of container ports on manufacturing industries in the period from 2003 to 2011.

5.4.4. Moderating effects

The thesis tests an interaction between independent variables. Since Chapter 5 analyses the effects of port activity on output of leather, bag and shoe industry in Korea, we first test the moderating effects around container throughput of Korean container ports: moderating effects of container throughput of Korean container ports on the correlations between output of Korean manufacturing and other independent variables. The thesis tests the moderating effects through a general regression method as shown in of Equation 4.2.

Table 5.7: Moderators in panel data models in Chapter 5

Four moderators for moderating effects
interact1= normalization value of container throughput * normalization value of intm interact2= normalization value of container throughput * normalization value of tanyd interact3= normalization value of container throughput * normalization value of wages

`

Table 5.8: Moderating effects of regional panel in Chapter 5

Item/Model	GLS Panel corr					
	Model 5.2.1	Model 5.2.2	Model 5.2.3	Model 5.2.4	Model 5.2.5	Model 5.2.6
Intercept	1807	1801	989	1103	2199	1644
Wages	2.72***	2.76***	2.72***	2.68***	2.75***	2.71***
Capital	0.07	0.14	0.16	0.20	0.14	0.15
Intermediates	1.34***	1.36***	1.34***	1.34***	1.35***	1.35***
Container throughput	10.14***	1.46	2.61**			
Revealed comparative advantage	–939***	–864***	–1148**	–1245***	–766***	-981**
Road	-7.09***	-5.87***	-6.31***	-6.46***	-5.75***	-6.01***
Tonnage of cargoes	- -	-	-	0.23***	-0.17	-0.13
Interact 1	1025.36	-	-	1376.25		
Interact 2	-	4431.60***	-	-	4166.46***	
Interact 3	-		1979***	-	-	1555**
Sample size	304	304	304	304	304	304
χ^2	25362	35685	25237	19269	34555	22812
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

This Chapter generates three moderators for examining moderating effects as shown in the Table 5.7: first moderator between container throughput of container ports in moving average (mportth) and intermediates (intm); second moderator between mportth and capital (tanyield); and third moderator between mportth and wages (wages). We calculate three moderators after normalization of these variables.

While adopting a similar method of Equation 4.2 in the examination of moderating effects between container throughput of container ports and the regional variables of manufacturing industries, we find an interaction between container throughput of container ports and capital input as shown in Model 5.2.2 in Table 5.8, and between container throughput and labour input as shown in Model 5.2.3 in Table 5.8. Although these moderating effects show robustness in the models, Model 5.2.5 and 5.2.6, for robustness check, the coefficients of main variables such as cargo tonnage inside containers and capital are inconclusive. In the robustness test we replace container throughput of container ports with cargo tonnage inside containers of container ports. Hence, we cannot conclude that port activity improves the positive effects of capital and labour inputs on output of Korean leather bag and shoe industry.

5.5 Discussions

5.5.1 Analysis by region

While using Model 5.1.3 of GLS estimator in heteroscedastic disturbance with cross-sectional correlation (GLS panel corr) as shown in Table 5.5, we can divide the country into two groups of regions as listed in Table 5.9: a group of regions with a large port, Busan (BS) and Incheon (IN), and the other group of regions except Busan and Incheon. In the group of the large port, we find inconclusive effects of container throughput on production in Model 5.3.1 encompassing the whole period; Model 5.3.2 in the period from 1993 to 2002; and Model 5.3.3 in the period from 2003 to 2011. After adding Gyeonggi region where Pyeongtaek Port locates into the group with large port, we get similar results.

Table 5.9: Results of panal data model for two groups of regions

Item/model	GLS panel corr					
	M 5.3.1	M 5.3.2	M 5.3.3	M 5.3.4	M 5.3.5	M 5.3.6
Period	1992–2011	1992–2002	2003–2011	1992–2011	1992–2002	2003–2011
Region	BS and IN			Except BS and IN		
Intercept	–3668	29034	-15823	3993	4040	3654
Wages	2.94***	3.27***	5.45**	4.49***	3.39***	5.31***
Capital	–2.23	–2.21	–16.9	2.74***	1.19***	3.98***
Intermediates	1.10***	0.62**	0.88***	1.21***	1.09***	1.11***
Container throughput	8.84	–63.3	–20.5	–7.47***	–16.8***	-27.9
Revealed comparative advantage	–3668	6782	-326199	1363***	1510***	–842677***
Road	-65.4	-98.9	-70.1	-1.86***	-3.04***	-6.97***
Sample size	38	20	19	266	140	126
χ^2	687	207	605	7452	14904	3168
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% level; ***significant at 1% level.
BS: Busan; IN; Incheon.

Source: Author’s elaboration based on the data of Statistics Korea (1991–2011).

In the other region without a large port, we obtain negative coefficients of container throughput on production in Model 5.3.4 from 1992 to 2011 and in Model 5.3.5 during the period from 1993 to 2002. Nevertheless, Model 5.3.6 demonstrates an inconclusive effect of container throughput. Regression results show that the group of regions without a large port mainly experiences negative effects of container throughput on production in the 1990s and the early 2000s.

The Herfindahl Hirschman index (HHI) informs us about the degree of concentration of an economy. HHI of output of the considered industrial sectors shows very little change from 0.30 in 1991 to 0.28 in 2011, as illustrated in Figure 5.3: HHI of employment illustrates a decrease from 0.44 to 0.28. At regional level, we can see a shift of main sources of output and employment from Busan to Gyeonggi region near Seoul, the capital city of Korea.

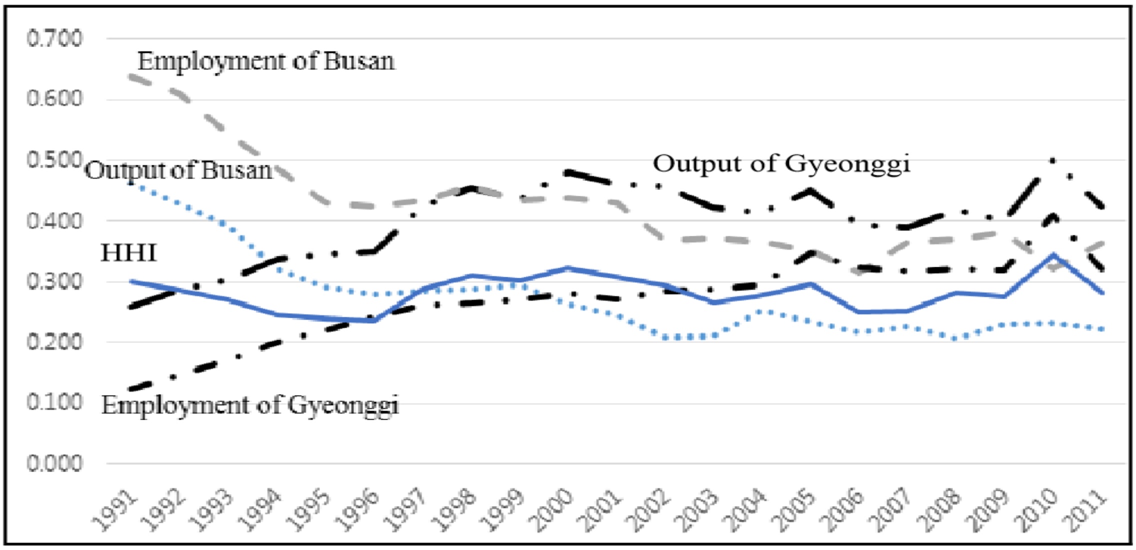

Figure 5.3: HHI and shares of output and employment in Busan and Gyeonggi region
Source*:* Author’s elaboration based on the data of Statistics Korea (1991–2011).

Busan did accumulate the growth potential, partly due to geographical location as a port city until the early 1990s (Shin, 2004). However, it shows a decrease of shares in output and employment in the industry from 1991 to 2011 as shown in Figure 5.3: the share of output fell from 0.46 to 0.22; and employment from 0.64 to 0.36. In addition, the effects of container port in Busan on the industry are inconclusive in the panel data models as shown in Table 5.9. Hence, these imply that a decrease of shares of Busan in output and employment from 1991 to 2011 was not caused directly by port development but by other factors such as relatively higher labour costs.

Table 5.10: Number and average age of establishments in Busan and Gyeonggi region

Item	1991		2002		2011	
	Busan	Gyeonggi	Busan	Gyeonggi	Busan	Gyeonggi
Number	796	410	415	237	238	194
Average age (Year)	4.34	5.21	6.08	8.69	8.54	11.30

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

Gyeonggi region near the Seoul Metropolitan Area embraces a few representative factories of leather bag and shoe makers in Korea such as Esquire and Kumkang, which are selling their outputs mainly in domestic markets. Shoe makers, including these two representative makers, led the employment, output and value added in the leather, bag and shoe industry since the mid of 1990s (Kim et al., 2008). Although Busan region shows a continual decrease of shares in accordance with the positioning changes of the industry and Gyeonggi region demonstrates a concentration of output and employment in proportion to the growth of imports, the effects of a container port on production of the industry are inconclusive for the group of regions with a large port. The average age of establishments in Gyeonggi shows lengthier longevity of establishments in the region than that of Busan: the average age in Gyeonggi extended from 5.21 year in 1991 to 11.30 year in 2011; Busan from 4.34 year to 8.54 year as illustrated in Table 5.10. This means that the manufactures near the largest domestic market show a higher possibility of survival even with the influx of imports.

5.5.2 Analysis on relationship between transshipment and the leather, bag and shoe industry

In an industry level, we test the effects of transshipment activity of container ports on output of the leather, bag and shoe industry in Korea while using the regional panel data of the industry. The thesis builds panel data models of linear regression: models of generalized least squares (GLS) estimators.

Model 5.5.1 and Model 5.5.2 in Table 5.11 include dependent variable of output of the industry; Model 5.5.2 with dependent variable of value added of the industry. Models uses independent variables of wage, capital, intermediates, transshipment throughput of Busan Port, transshipment container throughput of Korean ports, revealed comparative advantage, and road length. The panel data models of Model 5.5.1 and Model 5.5.2 in Table 5.11 demonstrate inconclusive effects of transshipment activity of container ports. Although Model 5.5.3 shows a negative effect, the coefficient of capital input also is negative. Hence, Model 5.5.3 illustrates unreasonable results

Table 5.11: Panel data models of transshipment movements in Chapter 5

Variables /model	Model 5.5.1, GLS	Model 5.5.2, GLS	Model 5.5.3, GLS
Dependent	Output		Value added
Intercept	2112	331	-1.47
Wages	2.7***	2.7***	0.001***
Capital	0.11	-2.21	-0.001***
Intermediates	1.35***	1.14***	0.001***
Transshipment container of Busan Port	-0.70		-0.001**
Transshipment container of Korean ports	-	-0.52	-
Revealed comparative advantage	-1093	-245	-0.87
Road	-6.47	1.60	-0.001
Sample size	304	57	304
χ^2	807	807	6171
Probability > χ^2	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level. The figures in parenthesis mean t value at fixed effects models and z value at random effects model.

Source: Author’s elaboration based on the data of Statistics Korea (1991–2011).

5.5.3 Analysis of enduring establishments

The enduring establishments of the leather, bag and shoe industry had been active in production from 1991 to 2011. The thesis gathers the data of 37 enduring establishments. In the test of model suitability for panel of enduring establishments, we obtain a similar result to Table 5.4 as shown in Table 5.12. Hausman test shows us the efficiency of estimators of random effects model in comparison with fixed effects model. The statistics on autocorrelation do not reject the null hypothesis of no autocorrelation and the thesis finds the heteroscedasticity of the disturbance. These results suggest that random effects model has efficiency in estimators and generalized least squares (GLS) estimators are more efficient than estimators of random effects model. Hence, the thesis selects mainly models of GLS estimator in heteroscedastic disturbance term with cross-sectional correlation (GLS panel corr).

Table 5.12: Summary of suitability tests for models in Chapter 5

Test	Results
Hausman test	$\chi^2(6) = 4.32$; Prob. > χ^2: 0.63
Wooldridge test of autocorrelation in panel data	F(1, 4) = 0.001; Prob. > F = 0.97
Likelihood-ratio test of homoscedasticity	$\chi^2(15) = 2{,}944$; Prob. > χ^2: 0.000

Note: Prob. means probability.
Source*:* Author's elaboration based on the data of Statistics Korea (1991–2011), Ministry of Oceans and Fisheries of Korea (2017), and Author's elaboration

In the analysis of enduring establishments of the leather, bag and shoe industry, the thesis uses two types of dependent variables: output and value added by the leather, bag and shoe industry in Korea. The independent variables also include wages, capital, intermediates, container throughput of container ports, revealed comparative advantage of the industry, and road length from 1991 to 2011. Data in the models of enduring establishments of the leather, bag and shoe industry are difference format between value of present year and value of the previous year. In addition, two independent variables, container throughput of container ports and revealed comparative advantage of the industry take the form of moving average as shown in Equation 5.3 and 5.4.

The thesis builds the models of GLS estimator in heteroscedastic disturbance term with cross-sectional correlation (GLS panel corr) with dependent variable of output of leather, bag and shoe industry in Korea: Model 5.4.1, Model 5.4.2, and Model 5.4.3 as shown in Table 5.13. Model 5.4.1 includes the data of the period 1992-2010; Model 5.4.2 in the period 1992-2002; and Model 5.4.3 in the period 2003-2011. Model 5.4.4, Model 5.4.5, and Model 5.4.6 have dependent variable of value added of leather, bag and shoe industry in Korea and the same independent variables of Model 5.4.1. Similarly to the analysis of Model 5.4.1, Model 5.4.2, and Model 5.4.3, Model 5.4.4 contains the data of the period 1992-2010; Model 5.4.5 in the period 1992-2002; and Model 5.4.6 in the period 2003-2011.

Table 5.13: Panel data model results of enduring establishments

Item/model	GLS Panel corr					
	M 5.4.1	M 5.4.2	M 5.4.3	M 5.4.4	M 5.4.5	M 5.4.6
Dependent	Output			Value added		
Period	1992–2011	1992–2002	2003–2011	1992–2011	1992–2002	2003–2011
Intercept	639	675	–570	538	553	627
Wages	0.96***	1.39***	1.39***	1.01***	5.41***	0.24
Capital	2.63***	4.23***	5.39***	2.90***	0.71	5.32***
Intermediates	0.56***	0.37***	0.69***	-0.15***	-0.72***	0.01
Container throughput	–0.32***	1.28	0.32	–0.31***	0.14	–0.39
Revealed comparative advantage	170***	165	–1,969	216***	204	-6,649**
Road	-1.01***	-0.65	2.39	-0.80***	0.41	0.81
Sample size	703	370	333	703	370	333
χ^2	1242	152	140	1231	981	50
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: * significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Source: Author’s elaboration based on the data of Statistics Korea (1991–2011).

Although Model 5.4.1 in Table 5.13 presents a negative coefficient of container throughput on production, Model 5.4.2 and Model 5.4.3 show an inconclusive coefficient of port throughput. Similarly, Model 5.4.4 illustrates a negative coefficient of container throughput on value added of the industry. Nevertheless, in Model 5.4.5 and Model 5.4.6 we find inconclusive effects of port throughput on production.

In the enduring establishment panel of Table 5.13 we obtain contradictory results for the regional panel, which shows positive effects from 1992 to 2011 but negative ones from 1992 to 2002 as shown in Model 5.1.3 and Model 5.1.4 of Table 5.5. This may be caused by the characteristics of the two different panels. While the regional panel includes diverse establishments, the enduring establishment panel contains only competitive establishments that kept producing from 1991 to 2011, despite the fact that TSI and RCA have verified lower competitiveness in the considered industrial sector.

5.6 Conclusions

This Chapter has evaluated the effects of container throughput in Korea on the output of the leather, bag and shoe industry from 1991 to 2011. The industry in Korea experienced severe competition with foreign competitors in developing countries in Asia, and diminished its production capacity and employment since the late 1980s. Starting as an exporter, the leather, bag and shoe industry fairly rapidly turned into an importer by 2003. In the port business, the port of Busan evolved into a hub in North-East Asia in the early 1990s. With regard to the leather, bag and shoe industry, we have tested how port development impacts on an industry that underwent rapid change in the global economy. For this purpose, we used two panel datasets pertaining to the leather, bag and shoe industry from 1991 to 2011: regional panel data and panel data of enduring establishments.

We found in the regional panel data models that an increase of container throughput in Korean ports positively affects the output of the industry from 1992 to 2011. The implication here is that Korean ports played a positive role in the development of the leather, bag and shoe industry and the business clustering. Second, if we divide the examined period into two, an increase of container throughput negatively affected the output from 1992 to 2002 and positively from 2003 to 2011. The negative effects of increase of container throughput imply disaggregation of existing clusters in proportion to a decreasing ratio of exports. Third, the positive effect of container throughput in the regional panel from 2003 to 2011 signals that the effect of a container port works in both directions of cargoes: inbound and outbound. Fourth, we find negative effects in the group of regions without larger port, both in the whole period and in the period from 1992 to 2002. Therefore, the regions are affected negatively as the industry transformed from exporting to importing industry. Fifth, the negative effects of port throughput in the enduring panel datasets imply that the enduring establishments experienced negative effects in accordance with growing import. Seventh, we find that transshipment activity of Korean container ports does not affect the output of the leather, bag and shoe industry in Korea.

The main results of this Chapter suggest some implications for policy makers. First, it is necessary for policy makers to assess separately the effects of port development on leading regional manufacturing industries. Although the aggregated regional effects present policy makers an indicator of feasibility, some manufacturing industries may be exposed more broadly to foreign competitors and shift their plants from the region to foreign countries. In the Korean Government, eagerness to develop transport hubs may have overlooked the potential harms caused to local manufacturing infrastructures. Second, the role of ports, especially container ports, is affected by the changes of manufacturing in global trade. Although Busan Port, as the main hub port in Korea, played a gateway for exports of the industries until the early 2000s, Incheon Port has increased its importance in handling imports since the early 2000s. Hence, a balanced policy on port development between Busan Port and other ports could reduce the logistics costs of shippers. Third, the different aspects of regional effects of container ports signal stakeholders to respond optimally to changes of manufacturing industries in proportion to port expansion. A region embracing manufacturers with decreasing comparative competitiveness in global trade may face diminishing manufacturing both from decreasing exports and an increasing influx of goods, particularly if the region does not have a hub container port.

This Chapter represents our attempt to shed light on the regional effects of port development on manufacturing in Korea. However, the analysis has a number of limitations. Firstly, detailed responses from manufacturers about the impacts of port development on individual establishments of the leather, bag and shoe industry would add useful information to the present study. Secondly, a comparison with other types of industries such as warehousing could provide deeper insights into the relationship between port development and manufacturing. Thirdly, we think that spatial weight of transport costs and spatial weight regression studies should also be carried out. Fourthly, the thesis would have benefitted from using panel data of freight rates of container shipping routes by identifying which factors influence the direction of trade in the global market, as studied by Krugman (1980) and Behrens and Picard (2011). Fifthly, comparison with cases of other manufacturing industries may provide us with other sides of the relationships between container port and manufacturing industry.

In Chapter 6, we will explore another specific manufacturing industry, the automobile industry. In contrast to the leather, bag and shoe industry, the production factories of the automobile industry locate at geographically scattered regions. The examination of economic effects of container ports on the automobile industry in Korea shows another aspect of economic interaction between a container port and its region.

6. Spatial Development Effects of Container Ports on the Automobile Industry in Korea

6.1. Introduction

Chapter 5 reviewed the effects of Korean container ports on the leather, bag and shoe manufacturing industry, which was a labour intensive industry in Korea. The labour intensive manufacturing industry in Korea faced demand diminution from global players and relocated many of their plants to other countries with low-cost labour. Chapter 5 showed that the effects of container ports on a specific manufacturing industry are diverse, and have many aspects by period and by region: negative, inconclusive, and positive effects. The industry of leather, bag and shoe manufacturing was a representative exporting industry and a main employment source in Busan in the 1970s and even in the 1980s.

When we examined the economic effects of container ports on the regionally aggregated output and input of manufacturers in Chapter 4, we observed positive effects on the output of manufacturing industries. Nevertheless, in Chapter 5 we can see that the effects of container ports on the output of the leather, bag and shoes industry demonstrate both positive and negative coefficients in accordance with different periods and different regions. Hence, it is important to verify that economic effects from container ports on the regional economy of Busan and the wider Korean economy in other manufacturing industries can vary. We explore this further by looking at the automobile industry, after collecting data of each establishment of the automobile industry in Korea.

The automobile industry has been a main propeller of the Korean economy. It provides 333 thousand jobs, accounting for 11.6% of the total Korean manufacturing industries workforce: 85 thousand jobs of finished automobile manufacturing and 248 thousands jobs of parts manufacturing in 2015 (Korea Automobile Manufacturers Association, 2016). Although Korean automobile manufacturers such as Hyundai Automobile and Kia Automobile moved some plants to foreign countries, the employment and the output of the automobile industry in Korea have grown continually (Kim, 2011).

The Korean automobile industry began by producing cars by the semi-knock down (SKD) assembly of imported parts from foreign makers in the 1960s (Lee et al., 1996; Kim, 1998; Truett and Truett, 2014). The knock down kits are parts and components of automobiles, which could be assembled into an automobile in a country of import. The automobile industry has been classified as an Industry Code of 30 by the Statistics Korea since 2007, and is comprised of automobile manufacturing, automobile engine manufacturing, automobile body and trailer manufacturing, manufacturing of automobile engine parts and trailer parts, and manufacturing of other auto parts. From the view of a port, finished automobiles are exported to foreign countries mainly through automobile terminals, which use the system of roll on-roll off (RO/RO), whereas parts and knock-down kits of automobiles in a container are transported through container terminals. The export of passenger automobiles by Korean automobile manufacturers amounted to 37.5 billion dollars in 2015; export of parts and accessories of automobiles, 21.8 billion dollars (Korea Customs Service, 2016).

Although major automobile manufacturers such as Hyundai Automobile, Kia Automobile, and Daewoo Automobile have been located, respectively, in Ulsan, Gwangju and Incheon since the 1960s, newcomer Samsung Automobile headquartered its factory in

Busan in the 1980s. Before the Asian financial crisis of the late 1990s, the industry had been characterised by constant growth and production development. In the early 2000s, however, two Korean automobile makers were sold to foreign makers: Samsung Automobile went to Renault in 2000 and Daewoo Automobile was purchased by General Motors in 2002.

Nevertheless, Korean automobile manufacturers face a new environment of competition from foreign manufacturers. The finalising of the most recent Free Trade Agreement (FTA) in 2012 between Korea and the United States now gives Korean manufacturers opportunities to enlarge their global shares, as well as the ability to further attract foreign makers, by lowering customs tariffs and other barriers in Korea. Customs tariffs on automobiles have until recently hindered imports of foreign cars. The tariff of Korea was 50% until 1987, reduced to 40% in 1988, 20% in 1990, 10% in 1994, and 8% in 1995. Customs tariffs on automobile parts remains at 8%. The FTA between Korea and its main trading partners, the United States and the EU may liberalize the Korean automobile market even more widely to foreign makers.

In order to gain insights into the intricate relationships between the manufacturing and shipping industries in Korea, we examine the effects of the expansion of container ports on the spatial development of automobile manufacturers in Korea. Section 2 describes the literature on the relationship between a port and its regional economy, and a port and the automobile industry. Section 3 describes our data collection. Section 4 explains the panel data models and main results from the regression analysis. Section 5 further discusses the analysis by dividing the examined regions in accordance with 16 administrative regions in Korea. Section 6 concludes this Chapter.

6.2. Literature review

Transport plays a pivotal role in the development of industries (Ng and Gujar, 2009), regional integration and specialization in foreign trade (Krugman and Venables, 1996), and in the promotion of foreign trade, even in the economies of land-locked and lower accessibility countries (Behrens et al., 2009). From this view, by enabling economic players to share inputs, outputs and technology, ports have become the main ‘promoters’ of agglomeration and regional integration. However, the development and expansion of a port may yield both positive and negative regional effects. Port development in a region can lower transport costs and improve punctuality in supply and procurement. It can also encourage the influx of foreign goods including intermediates such as parts and components from neighbouring regions and foreign countries (Stevens et al., 1981). In some of the port literature, authors stress the positive regional effects through the analysis of I-O table, counting employment from port activity, use of regional growth equations, and other econometric models, which identify economic effects (Acciaro, 2008; Bottasso et al., 2013; Bottasso et al., 2014; Shan et al., 2014). These approaches provide us with useful aggregated effects but without specific effects on each industry.

Recent papers on the economic effects of a port have also analysed regional aggregated effects (Yu et al., 2013; Bottasso et al., 2014; Shan et al., 2014). However, they have not identified the specific effects of a port on each industry (in our case automobile manufacturing). Literature on the relationship between a port and the automobile industry tends to review the transport system of finished vehicles, for example roll on-roll off (RO/RO) terminal (Hall, 2004; Fisher and Gehring, 2005). Since the Korean automobile industry exports both finished automobiles and knock down kits of automobiles as well as parts of automobiles, and imports vehicles and parts of automobiles, the industry might be affected by the development of container ports in Korea. Guerrero and Itoh (2017) explore the relationship between the automobile industry and regional ports in Kyushu, Japan. In relation to Korea, they point to the international division of manufacturing between Japanese automobile manufacturers and low-cost suppliers of automobile parts in Korea through assistance of frequent shipping services between Busan Port and Kyushu ports (Guerrero and Itoh, 2017). Koo (2013) also focuses on the role of container transport in Busan Port when analysing the international transport of automobile parts trade between Korea, China and Japan, and finds that automobile parts in Korea are transported mainly by container system and through Busan Port.

Accepting the findings of Guerrero and Itoh (2017), and Koo (2013), the thesis reviews further the relationship between Korean container ports and the automobile industry. By narrowing the examination between a container port and the automobile manufacturing industry, the thesis can specify the economic effects of port development when policy makers decide policy for port development and regional manufacturing industries. As the automobile industry is a key part of the Korean economy, we expect that this Chapter will therefore be essential in studying the effects of Korean port expansion on the development of the industry in the future.

6.3. Data description

6.3.1 Data collection

In 2011 the Korean automobile industry took a share of 6.8% of the total workers, 7.7% of output, and 8.5% of value added in total manufacturing industries, increasing respectively from 4.9%, 7.1%, and 6.7% in 1991 (Statistics Korea, 1991-2011). The industry recorded long-term growth from the 1960s, but experienced huge losses during the economic recession of the late 1990s to early 2000s. After the recession, however, it recovered its competitiveness and today is a major pillar of the Korean economy.

This Chapter collects data on the automobile industry from the Statistics Korea, which include data of time series of regional establishments from 1991 to 2011, panel data of industrial complexes from 1993 to 2011, and panel data of enduring establishments from 1991 to 2011. Among this data, the panel data of industrial complexes and the panel data of enduring establishments are not full of information from all the 16 administrative regions. We have therefore built the regional panel data from the data of regional establishments from 1991 to 2011. Though a shortcoming worth mentioning is that we have not observed the same establishments from 1991 to 2011 and do not have the data of Jeju region, which doesn't accommodate any automobile industries. We have also assembled data on container throughput and the number of quay cranes and their mechanical characteristics at container ports in Korea from the Ministry of Oceans and Fisheries (MOF).

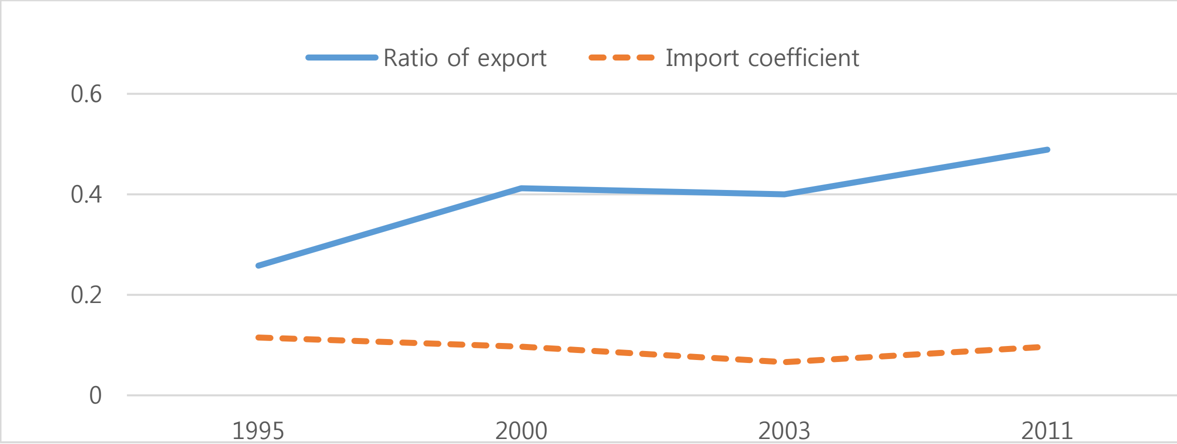

Figure 6.1: Ratio of export and import coefficient of automobile manufacturing in Korea
Source: Author's elaboration on the data of Bank of Korea (1995-2011).

It is noteworthy that we found an indication of a strict relationship between the automobile industry and port activity in the statistics of the ratio of export and industrial complex in the automobile industry. In Figure 6.1 we observe that the ratio of export is about 50% in 2011, and the import coefficient is about 10% (Bank of Korea, 2014).

6.3.2. Data description

The main data on the automobile industry comprise number of workers (workers), amount of output (output), wages (wages), costs of intermediates (intermediates), total cost (ttlcost), value of tangible assets (tanass), and yield for tangible assets (tanyield), which is calculated by the multiplication of tangible assets and yield of corporative bonds from 1991 to 2011. Data of port development include container throughput (portth) and container handling capacity (portcapa) of the regional port. Table 6.1 summarizes the characteristics of each variable across the top: number of observations, mean value, standard deviation, minimum value, and maximum value. Table 6.2 shows the correlation coefficient matrix between the main variables. Since the container throughput of each regional container port (portth in Table 6.2) demonstrates negative correlation coefficients with other production variables such as output and value added (valadd), this Chapter adopts the container throughput of Busan Port (bsportth in Table 6.2) as an indicator of port activity in Korea, which demonstrates positive correlation coefficients with other production variables.

Table 6.1: Summary of input data

Variable	Obs	Mean	Std. Dev.	Min	Max
Workers (person)	504	1,574	2,539	13	12,490
Output (million Korean won)	504	385,286	801,682	712	6,666,579
Wages (million Korean won)	504	38,212	71,950	116	483,902
Intermediates (million Korean won)	504	226,473	505,217	93	4,277,877
Ttlcost (million Korean won)	504	432,771	886,187	712	6,039,949
Tanass (million Korean won)	504	26,756	67,655	13	589,276
Yield	504	.081	.036	.044	.15
Tanyield (million Korean won)	504	1,970	5,589	.672	60,453
Portcapa (thousand TEU)	504	646	2,557	0	22,448
Portth (thousand TEU)	504	409	1,736	0	15,523

Source: Author's elaboration on the data of Statistics Korea and the Ministry of Oceans and Fisheries.

Table 6.2: Correlation coefficients among major variables

Variable	output	valadd	tanass	wages	rawcosts	tanyield	emp
output	-	0.985	0.879	0.989	0.996	0.879	0.895
portth	-0.327	-0.341	-0.349	-0.357	-0.317	-0.395	-0.347
bsportth	0.355	0.294	0.261	0.347	0.381	0.083	0.038
bsportton	0.384	0.320	0.276	0.378	0.410	0.095	0.067

Source: Author's elaboration on the data of Statistics Korea and the Ministry of Oceans and Fisheries.

Table 6.3: Panel unit root test of Fisher-ADF in automobile industry

Variables/ Items	ρ value	
	Levels of logarithm	Differences
Output	0.000	0.000
Wages	0.000	0.000
Capital	0.000	0.000
Intermediates	0.002	0.000
Container throughput of Busan Port	0.986	0.000
Cargo tonnage inside containers of Busan Port	1.000	0.000
Revealed comparative advantage	0.000	0.000
Road	0.103	0.000

Note: p value indicates the probability of unit root based on the value of inverse χ^2 at Fisher type unit root test LLC; p value at Fisher-ADF represents the value of inverse chi-squared.

Source: Author's elaboration on the data of Statistics Korea and the Ministry of Oceans and Fisheries.

In the panel unit test, container throughput of Busan Port (bsportth), cargo tonnage of container throughput of Busan Port (bsportton) and road length in logarithm formation at each region show a unit root (Table 6.3). Differences of logarithm formation variables illustrate the improvement of stationarity in the two variables. Hence, this Chapter uses differences of logarithm formation variables in the analysis.

6.3.3 Microeconomic models

We use the production function for regression on output as shown in Chapter 4. The production function includes the value of regional output and inputs of different establishments of automobile manufacturing, as shown in Equation 6.1: output, labour, capital, intermediates, and port indicators such as container throughputs or cargo tonnage of container throughput of a port.

$$Y = F(L, K, IM, PT) \quad (6.1)$$

Where,

Y: output of automobile manufacturing establishments,

L: labour input,

K: capital input,

IM: inputs of intermediates,

pt: container throughputs or cargo tonnage of container throughputs.

The thesis adopts the basic production function of the microeconomic approach by Cobb and Douglas (1928), who measured the productivity of American manufacturing industries and proposed a production function in log-linear format. Arbues et al. (2015) use the Cobb - Douglas production function in order to examine the effects of transport infrastructures on the regional productivity in Spain. Considering the assertion by Musso et al. (2006) who evaluate port investment as an increase in capital goods, which would indirectly improve the efficiency in production, the thesis develops the following empirical model of Cobb - Douglas production function.

$$y = a1 + a2\, l + a3\, k + a4\, im + a5\, pt + a6\, rd + a7\, RCA + \varepsilon \qquad (6.2)$$

In the Equation 6.2 *y*, *l*, *k*, *im*, *pt* and *rd* represent differences of natural logarithms of variables of output, wages as a proxy for labour input, capital inputs, intermediates, port throughput and length of road in year t. RCA means revealed comparative advantage of the Korean automobile industry. Equation 6.2 includes a disturbance term, ε. For example, *y* means the difference between natural logarithm of output in year t and natural logarithm of output in year t-1.

6.4 Panel data models and results

6.4.1 Suitability of models

The thesis tests the classical assumptions on the random disturbance in Equation 6.2. The thesis adopts a few tests for selection of panel data model: Hausman test, test for autocorrelation in disturbance, and test for homoscedasticity of disturbance (Greene, 2008; Gujarati, 2003). The Hausman test demonstrates better efficiency of random effects model as shown in Table 6.4. The result of Wooldridge test shows autocorrelation of panel data. We find heteroscedasticity in disturbance term of the panel data in likelihood-ratio test.

Table 6.4: Summary of suitability tests for models of regional panel

Test	Results
Hausman test	$\chi^2(6) = 0.01$; Prob. > χ^2: 1.00
Wooldridge test for autocorrelation in panel data	$F(1, 14) = 14.8$; Prob. > F = 0.002
Likelihood-ratio test of homoscedasticity	$\chi^2(10) = 96.8$; Prob. > χ^2: 0.000

Note: Prob. means probability.
Source: Author's elaboration on the data of Statistics Korea (1991–2011) and Ministry of Oceans and Fisheries of Korea (2017).

Hence, this Chapter adopts first the panel data model of random effects model, the methods of generalized least squares (GLS) estimator, and the methods of generalized least squares estimator with heteroscedasticity of disturbance (GLS panel hetero). Then this Chapter will test moderating effects focused on the container throughput of Busan Port and other variables. Finally, this Chapter checks the robustness of the models.

6.4.2 Model description

All models in this Chapter adopt the method of linear regression model as shown in Equation 6.2. Following the results of suitability of models in Table 6.4, the thesis builds first random effects model, Model 6.1.1. Since Table 6.4 shows us autocorrelation of disturbance, the thesis develops a model of generalized least squares (GLS) estimator, Model 6.1.2. The other Models in this Chapter from Model 6.1.3 to Model 6.17 are using the methods of generalized least squares estimator with heteroscedasticity of disturbance (GLS panel hetero).

Table 6.5 has two dependent variables: output of the automobile industry in Korea in Model 6.1.1, Model 6.1.2, Model 6.1.3, Model 6.1.4, and Model 6.1.7; value added (valadd) of the automobile industry in Model 6.1.5 and 6.1.6. Model 6.1.1, Model 6.1.2, Model 6.1.3, and Model 6.1.6 use the independent variables of wages, capital, intermediates, container throughput of Busan Port, revealed comparative advantage of the automobile industry of Korea, and road length. Nevertheless, Model 6.1.7 uses cargo tonnage inside containers of Busan Port in place of container throughput of Busan Port in Model 6.1.3. While Model 6.1.4 excludes the independent variables of revealed comparative advantage and road length in comparison with Model 6.1.1, Model 6.1.5 has not the independent variable of road length.

6.4.3 Results of panel data model

The thesis calculates estimators of coefficients of independent variables through STATA (Statistics Data Analysis) 14 program. After changing the raw data of the Statistics Korea into the data file of STATA, the thesis checks missing values and the format of panel data. Since the thesis collected the panel data of Korean manufacturing, the thesis uses panel data models.

Table 6.5 summarizes panel data models and the main results. Random effects model, Model 6.1.1 and model of generalized least squares estimator, Model 6.1.2 show inconclusive effects of container throughput on the outputs of the automobile industry. The panel data models of generalized least squares estimator with heteroscedasticity in disturbance of panel (GLS hetero) show positive coefficients of container throughput on the outputs or value added of the automobile industry in Model 6.1.3, Model 6.1.4, Model 6.1.5, and Model 6.1.6. The road length shows inconclusive effects on the outputs or value added of the automobile industry in Model 6.1.1, Model 6.1.2, Model 6.1.3, Model 6.1.6 and Model 6.1.7.

Table 6.5: Panel data models of regional panel in Chapter 6

Item/Model	Model 6.1.1 Random Effects,	Model 6.1.2 GLS	Model 6.1.3 GLS Panel hetero	Model 6.1.4 GLS Panel hetero	Model 6.1.5 GLS Panel hetero	Model 6.1.6 GLS Panel hetero	Model 6.1.7 GLS Panel hetero
Dependent	output				valadd		output
Intercept	-0.0005	-0.0005	-0.004				-0.004
Wages	0.22***	0.22***	0.25***	0.07**	0.07**	0.07**	0.25***
Capital	0.09***	0.09***	0.04***	0.86***	0.88***	0.88***	0.04***
Intermediates	0.68***	0.68***	0.70***	0.07**	0.05*	0.05*	0.70***
Container Throughput of Busan Port (bsportth)	0.07	0.07	0.09*	0.42***	0.44***	0.44***	-
Revealed comparative advantage (rca)	0.001	0.001	0.0004	-	-0.02***	-0.02***	0.001
Road	0.01	0.01	0.01	-	-	-0.01	0.01
Tonnage inside containers of Busan Port	-	-	-	-		-	0.06*
R^2	0.98						
Sample size	285	285	285	286	286	285	285
χ^2	18317	18778	28437	8763	9554	9538	29247
Probability>χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author's elaboration on the data of Statistics Korea (1991–2011).

Model 6.1.4, Model 6.1.5, and Model 6.1.6 of panel data models without intercept as an independent variable demonstrate larger coefficients of container throughput of Busan Port on outputs of the industry than Model 6.1.3. The revealed comparative advantage (RCA) shows negative coefficients in Model 6.1.5 and Model 6.1.6. The negative effects of RCA seem to be caused by the globalization of the Korean automobile industry, which occurred largely in the 2000s in order to enhance cost competitiveness by moving plants into countries of low labour costs, and increased production in foreign countries such as India, China and America (Kim, 2011).

This Chapter checks the robustness of the results of panel data models in Model 6.1.3 and Model 6.1.4. These models show us a positive correlation between outputs of the industry and container throughput of Busan Port. First, this Chapter uses the value added by the automobile industry as a dependent variable instead of outputs as shown in Model 6.1.5 and Model 6.1.6. Second, this Chapter adopts the cargo tonnage inside containers of Busan Port as listed in Model 6.1.7. In Model 6.1.5 and Model 6.1.6, we find that the coefficients of container throughput of Busan Port are positive and the coefficients of the other three independent variables including wages, capital, and intermediates are also positive. Model 6.1.7 demonstrates the robustness of results of Model 6.1.3.

It is clear then, that the activity of Busan Port has a positive relationship with the output of the automobile industry in Korea. Nevertheless, the effects of road as a representative of other transport infrastructure are inconclusive in the automobile industry. The inconclusive effects of road in the automobile industry coincide partially with Koo's study (2013). He finds that Busan Port has a strong tie with the Korean automobile industry by providing frequent shipping services and supporting international logistics.

6.4.4 Analysis by period

This Chapter tests the differences of panel data models by dividing the examined period from 1991 to 2011 into the two periods in accordance with changes in revealed comparative advantage (RCA). RCA increased from under 0.97 in 2000 to 1.18 in 2001. Therefore, this Chapter include the first period from 1992 to 2000 and the second period from 2001 to 2010. Since this Chapter uses differences of logarithms of variables, the data in 1991 and 2011 are not included.

Models in the analysis by period follow the methods of linear regression and generalized least squares estimator with heteroscedasticity in disturbance of panel (GLS panel hetero) in accordance with the results of Table 6.4. All Models in Table 6.6 include dependent variable of output of the automobile industry in Korea. Model 6.2.1, Model 6.2.2, Model 6.2.3, and Model 6.2.4 use the independent variables of wages, capital, intermediates, container throughput of Busan Port, revealed comparative advantage of the automobile industry of Korea, and road length. Nevertheless, Model 6.2.5 and Model 6.2.6 use cargo tonnage inside containers of Busan Port in place of container throughput of Busan Port. While Model 6.2.1, Model 6.2.2, and Model 6.2.5 use the data of period 1992-2000, the other Models include the data of period 2001-2010.

Table 6.6: Panel data models of GLS panel hetero of regional panel by period

Item/Model	Model 6.2.1	Model 6.2.2	Model 6.2.3	Model 6.2.4	Model 6.2.5	Model 6.2.6
Period	1992-2000		2001-2010		1992-2000	2001-2010
Intercept	-	0.01*	-	0.004		
Wages	0.44***	0.43***	0.12***	0.12***	0.45***	0.10***
Capital (tanyd)	-0.01*	-0.01***	0.19***	0.19***	-0.01*	0.22***
Intermediates	0.58***	0.60***	0.68***	0.68***	0.58***	0.65***
Container throughput of Busan Port (bsportth)	0.16***	0.05	0.11***	0.09**		
Revealed comparative advantage (rca)	-0.01***	-0.01***	0.001	0.001	-0.01***	0.002
Road	-0.21***	-0.20***	0.002	0.002	-0.20***	0.002
Tonnage inside containers of Busan Port	-	-	-	-	0.19***	0.18***
Sample size	120	120	165	165	120	165
χ^2	32457	35589	94322	88391	31883	93481
Probability> χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level.

Source: Author’s elaboration on the data of Statistics Korea (1991–2011).

Model 6.2.1 in Table 6.6 without intercept shows a positive coefficient of container throughput of Busan Port during the first period. However, the effect of container throughput of Busan Port is inconclusive in Model 6.2.2 with intercept during the first period. Model 6.2.4 with intercept and Model 6.2.3 without intercept show positive coefficients of the container throughput of Busan Port during the second period.

The coefficients of the container throughput of Busan Port stay positive in Model 6.2.5 and Model 6.2.6. Model 6.2.5 and Model 6.2.6 demonstrate similar values of coefficients of cargo tonnage during the two different periods. When we compare the coefficients of cargo tonnage inside containers of Busan Port in Model 6.2.5 and Model 6.2.6 with the coefficients of container throughput of Busan Port in Model 6.2.1 and Model 6.2.3, we find that their values are of a similar level.

This Chapter finds a positive relationship between the container throughput of Busan Port and the output of the automobile industry in the panel data models during the examined period. This implies that the Korean automobile industry may enjoy the development of container ports by forming international production networks in automobiles and automobile parts manufacturing (Kim, 2011; Koo, 2013).

6.4.5 Analysis by region

We examine the question of whether the regional effects of container ports vary in accordance with different regions in the automobile industry. As in the previous Chapter 4 and Chapter 5, we divide the regions into two sub-regions: port cities, Busan (BS) and Incheon (IN), which accommodate a big port or a big container port in Korea, and other regions without a big port or a big container port. Models in the analysis by region also follow the methods of linear regression and generalized least squares estimator with heteroscedasticity in disturbance of panel (GLS hetero) in accordance with the results of Table 6.4.

Table 6.7: Panel data models of GLS panel hetero by region

Item/Model	Model 6.3.1 BS,IN	Model 6.3.2 Other	Model 6.3.3 BS,IN	Model 6.3.4 Other	Model 6.3.5 BS,IN 1992-2000	Model 6.3.6 BS,IN 2001-2010
Wages	0.05	0.25***	0.06**	0.25***	0.08**	0.12***
Capital (tanyield)	0.30***	0.03***	0.30***	0.03***	0.31***	0.27***
Intermediates	0.60***	0.71***	0.59***	0.71***	0.55***	0.58***
Container throughput of Busan Port (bsportth)	0.24***	0.05				
Revealed comparative advantage (rca)	-0.01**	0.001	-0.01*	0.002	-0.0002	-0.004
Road	-0.11	0.01	-0.14	0.01	-0.21	-0.32*
Tonnage inside containers of Busan Port	-	-	0.31***	0.05	0.39***	0.31***
Sample size	40	245	40	245	29	31
χ^2	9391	28042	11725	27903	6608	31884
Probability > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level. The figures in parenthesis mean t value at fixed effects models and z value at random effects model.

Source: Author's elaboration on the data of Statistics Korea (1991–2011).

Models in Table 6.7 examine the effects of independent variables on the dependent variable, the output of the automobile industry in Korea. Models are composed of the dependent variable, output of regional manufacturing and independent variables: wages, capital input, container throughput of Busan Port or cargo tonnage inside containers of Busan Port, revealed comparative advantage (RCA), and road length. Model 6.3.1, Model 6.3.3, Model 6.3.5, and Model 6.3.6 analyse the effects of port development on the output of automobile industry in the regions of a big port, Busan and Incheon. Model

6.3.2 and Model 6.3.4 analyse the effects in other regions in Korea except Busan and Incheon; Model 6.3.2 with container throughput of Busan Port, an indicator of port development; and Model 6.3.4 with cargo tonnage inside containers of Busan Port. While Model 6.3.1 and Model 6.3.2 use container throughput of Busan Port as an indicator of port development, the other Models adopt cargo tonnage inside containers of Busan Port.

Model 6.3.1 in Table 6.7 focusing on the first regions with a big port shows that the regional effect of container ports is positive. Nevertheless, the other regions without a big port illustrate inconclusive effects of container ports in Model 6.3.2. While replacing container throughput of Busan Port with cargo tonnage inside containers in Model 6.3.3, we could find positive coefficient of cargo tonnage again. Model 6.3.5 and 6.3.6 prove that the positive regional effects of container ports occurred in port cities in different periods.

Moderating effect means an interaction between independent variables (Ali et al., 2016; Yang and Park, 2014; Yuen et al., 2016). Chapter 4 and Chapter 5 tested moderating effects through panel data models. This Chapter checked the between the container throughput of Busan Port and the regional variables in the industry, and the moderating effects between the container throughput of Busan Port and the regional variables by region and by period. We cannot find the moderating effects in the automobile industry.

6.4.6 Analysis of the relationship between transshipment and the automobile industry

Following the methods of linear regression, the thesis tests the suitability of panel data models as shown in Table 6.4. Table 6.4 suggest us the usage of random effects model, the methods of generalized least squares (GLS) estimator, and the methods of generalized least squares estimator with heteroscedasticity of disturbance (GLS panel hetero). In addition, Model 6.1.5 and Model 6.1.6 in Table 6.5 show superior results of estimators of independent variables including container throughput of Busan Port and revealed comparative advantage (RCA), compared to results of estimators in Model 6.1.1 of random effects model and Model 6.1.2 of GLS. Hence, the thesis uses models of GLS panel hetero in evaluating the transshipment activity of container ports on the output of the automobile industry in Korea.

Models in Table 6.8 examine transshipment activity of container ports on the output of the automobile industry in Korea. Models in Table 6.8 are composed of the dependent variable, output of or value added of the automobile industry and independent variables: wages, capital input, transshipment containers of Busan Port or transshipment containers of Korean ports, revealed comparative advantage (RCA) of the automobile industry, and road length. Model 6.4.1, Model 6.4.2, Model 6.4.3, and Model 6.4.4 adopt output the automobile industry as dependent variable but Model 6.4.5 uses value added of the automobile industry. All models except Model 6.4.2 employ transshipment containers of Busan Port as an indicator of transshipment activity of Korea. Model 6.4.2 adopts the other transshipment activity, transshipment containers of Korean ports. While Model 6.4.1, Model 6.4.2, and Model 6.4.5 use the data of period 1992-2010, Model 6.4.3 includes the data of period 1992-2000 and Model 6.4.3 with the data of period 2001-2010.

Although Model 6.4.1 shows a positive effect of transshipment containers of Busan Port, Model 6.4.2 demonstrates an inconclusive effect of transshipment containers of each port (Table 6.8). This Chapter divides the examined period into the two periods: the first period from 1992 to 2000 and the second period from 2001 to 2010. The coefficient of Model 6.4.3 shows an inconclusive effect of the transshipment containers of Busan Port during the first period. Model 6.4.4 illustrates a positive coefficient of the transshipment containers of Busan Port. While Model 6.4.5, which tests the robustness of the results of Model 6.4.1 shows a positive effect of the transshipment containers of Busan Port, Model 6.4.5 has inconclusive effects of wages and capital.

Table 6.8: Panel data models of transshipment movements in Chapter 6

Variables /Models	Model 6.4.1 GLS Panel (hetero)	Model 6.4.2 GLS Panel (hetero)	Model 6.4.3 GLS Panel (hetero) 1992-2000	Model 6.4.4 GLS 2001-2010	Model 6.4.5 GLS Panel (hetero)
	Dependent :output				Dependent : value added
Intercept	2112	0.03	0.004	0.004	0.02
Wages	0.25***	0.44	0.44***	0.12***	0.05
Capital	0.04***	0.29***	0.01	0.20***	0.91
Intermediates	0.69***	0. 62**	0. 56*	0.66***	0.02***
Transshipment containers of Busan Port	0.03*	-	0.03	0.06***	0.22***
Transshipment containers of Korean ports	-	0.01	-	-	-
RCA	0.0001	-0.007**	-0.01***	0.0001	-0.03***
Road	0.01	-0.60**	-0.13*	0.004	0.01***
Sample size	285	42	120	165	285
χ^2	28482	1998	23681	94953	11713
Probability > χ^2	0.000	0.000	0.000	0.000	0.000

Note: *significant at 10% level; **significant at 5% percent level; ***significant at 1% level. The figures in parenthesis mean t value at fixed effects models and z value at random effects model.

Source: Author's elaboration on the data of Statistics Korea (1991–2011).

Therefore, we can conclude that the effects of the transshipment activity of Busan Port on the output of the automobile industry in Korea have been positive during the second period, but inconclusive in the first period. This seems to have occurred due to the development of the international division of the automobile industry between Korea, China and Japan in the 2000s.

6.5 Discussions

We explore further the question of whether the regional effect of container ports can vary in accordance with different regions. The thesis accepts the suitability of panel data models as shown in Table 6.4 and the superiority of methods in generalized least squares estimator with heteroscedasticity of disturbance (GLS panel hetero) than the models of other methods as shown in Table 6.5. Hence, the thesis uses models of GLS panel hetero when evaluating the container throughput of Busan Port on the output of the automobile industry by different regions. The thesis follows the administrative zoning of 16 regions in Korea.

The regional panel data include production activity of the automobile industry in 15 regions, excluding Jeju. Among these 15 regions, region 21 (Busan), region 23 (Incheon), region 25 (Daejon), and region 31 (Gyeonggi) demonstrate positive coefficients of the container throughput of Busan Port on the output of the automobile industry as shown in Table 6.9. The development of Busan Port affects positively the output of the automobile industries in two port cities and two regions near Incheon Port and Pyeongtaek Port. Contrary to this however, region 37 (Gyeongbuk) shows a negative coefficient of the container throughput of Busan Port.

This Chapter checks the robustness of both the positive and negative effects in Table 6.10 by replacing the container throughput of Busan Port with the cargo tonnage inside containers of Busan Port. Table 6.10 shows the positive effects in the three regions of 21, 23, and 31, excluding region 25. Region 37 shows an inconclusive effect of the container throughput of Busan Port.

When examining the moderating effects between the container throughput of Busan Port and the regional variables in the industry, we can observe the positive moderating effect only between the cargo tonnage inside containers of Busan Port and intermediates in region 21 (Busan) as shown in Table 6.11. Hence, we can assert that the development of container ports in Busan does improve the productivity of intermediates of automobile manufacturers in Busan.

Table 6.9: Regional analysis of port development effects on the automobile industry

Variables/Regional code	11	21	22	23	24	25	26	31	32	33	34	35	36	37	38
C	0.02	0.02	0.01	0.01	0.03	-0.01	-0.01	-0.02	0.01	-0.002	-0.01	0.36	0.01	0.005	0.002
Wages	0.07	0.14***	0.19***	-0.01*	-0.05	0.38***	0.12	-0.17	0.08	0.25**	-0.03*	0.18	0.20***	0.21***	0.21***
Capital (tanyied)	0.27**	0.28***	-0.02**	0.29***	0.33***	0.23***	0.07	0.12***	0.22***	0.09	0.28***	0.15**	0.05	-0.03****	0.01
Intermediates	0.65**	0.55***	0.79***	0.66***	0.67***	0.32***	0.13***	0.98***	0.69***	0.68***	0.72***	0.62***	0.74***	0.75*	0.75***
Container throughput of Busan Port (bsportth)	-0.01	0.24*	-0.16	0.10**	-0.34	0.73**	0.16	0.44***	0.09	-0.03	0.17	-0.28	-0.67	-0.13**	0.06
rca	0.01	0.003	0.002	-0.01	-0.01	-0.01	0.01**	0.01*	-0.01	-0.01	-0.01	-0.01	0.02	-0.001	0.01**
road	-0.67	-0.62**	0.01***	-0.04	0.06	-0.73***	0.10	-0.15	-0.35	0.04	0.42	0.58	1.07	-0.33***	-0.24
χ^2	2981	5465	5721	6725	8289	372	18028	3860	3398	3078	2350	2835	600	6485	4524
Probability > χ^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: 1) * significant at 10 % level; ** significant at 5 % level; *** significant at 1 % level. .

2) C: Intercept; tanyield: yield of tangible assets; porth: container throughput of regional port; and rca: revealed comparative advantage.

Source: Author’s elaboration based on the data of Statistics Korea (1991–2011).

Table 6.10: Robustness check of regional analysis of port development effects on the automobile industry

Variables//Regional code	11	21	22	23	24	25	26	31	32	33	34	35	36	37	38
C	0.01	0.004	0.01	-0.003	0.01	0.02	-0.01	-0.02	-0.01	-0.02	-0.02	0.01	0.02	0.01	0.0003
Wages	0.08	0.15***	0.23***	0.01	-0.01	0.31***	-0.06	-0.07	-0.11	0.22*	-0.05	0.19	0.22	0.20**	0.21***
Capital (tanyied)	0.27***	0.28***	-0.02**	0.29***	0.34***	0.26***	0.08	0.14***	0.35**	0.10	0.29***	0.15**	0.05	-0.03	0.01
Intermediates	0.64***	0.53***	0.76***	0.65***	0.63***	0.35***	0.95***	0.86***	0.77***	0.70***	0.72***	0.61***	0.71***	0.75***	0.75***
Cargo tonnage inside containers of Busan Port	0.16	0.38***	-0.09	0.26**	0.16	0.36	0.12	0.32***	0.42	0.15	0.31*	0.04	-0.66	0.02	0.07
rca	0.01	0.01	0.001	-0.01	-0.01	-0.01	-0.01*	0.01	-0.004	-0.01	-0.004	-0.004	0.02	-0.001	0.01**
road	-0.69	-0.39	0.01**	-0.02	0.10	-0.57*	0.11	0.02	-0.24	0.01	0.36	0.51	1.05	-0.26**	-0.02
χ^2	3081	7418	5380	8344	8541	311	18850	3639	3629	3185	2647	2734	580	5314	4570
Probability > χ^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: 1) * significant at 10 % level; ** significant at 5 % level; *** significant at 1 % level. .

2) C: Intercept; tanyield: yield of tangible assets; porth: container throughput of regional port; and rca: revealed comparative advantage.

Source: Author's elaboration based on the data of Statistics Korea (1991–2011).

Table 6.11: Moderators by region

Item	wages	Capital: tanyied	intm	portton	rca	road	interact		
							1	2	3
Region 21	0.12***	0.29***	0.52***	0.041***	0.01	-0.46**	0.04*	-	-

Note: intm: intermediates; portton: cargo tonnage inside containers of Busan Port.
Source: Author’s elaboration based on the data of Statistics Korea (1991–2011).

6.6 Conclusions

This Chapter explores the relationship between a container port and the automobile industry in Korea. In order to examine the questions of this Chapter, we collect panel datasets of the Korean automobile industry and port activities. The relationship between the Korean automobile industry and port activities shows diversity by period and by region. Generally, the effects of a container port on the output of the automobile industry are positive. This is confirmed by the robustness test, which replaces the container throughput with the cargo tonnage inside containers. We find that the positive effects occur in a similar value in the two periods: the first period from 1992 to 2000 and the second period from 2001 to 2010. The panel data models in this Chapter demonstrate inconclusive effects of transshipment activity of container ports on the output of the automobile industry during the first period but show positive effects during the second period. The positive effects during the second period coincide with the globalization of the Korean automobile makers and the establishment of the international division in manufacturing automobile parts between Korea, China and Japan (Koo, 2013).

When dividing the examined 15 regions into the two sub-regions: the regions with a big port or a big container port and other regions. The regions with a big port demonstrate the positive effects of a container port on the output of the automobile industry but the other regions show inconclusive effects. In the examination of the effects of a container port at each of the 15 regions, we observe a similar result. The positive effects are observed in the two port cities, Busan and Incheon, and the neighbouring regions of Incheon.

In addition, the moderating effects between the container throughput of Busan Port and intermediates only occur in region 21 (Busan), where it accommodates a hub port in North-East Asia. This implies that the development of a container port in Busan helps the automobile manufacturers to get bettered productivity of intermediates through advanced shipping networks of Busan Port.

This Chapter and the previous two Chapters find diversity in the regional effects of Korean container ports on the manufacturing industries in Korea. Even though Korean container ports affect positively the output of Korean manufacturing industries in general, they have different impacts on each manufacturing industry by period and by region. From the analysis of moderating effects, we can find another pass of regional effects of Korean container ports. The activity of Korean container ports can enhance the productivity of inputs such as labour, intermediates including raw materials, and capital.

However, the effects of transshipment undertaken by Korean container ports on the output of manufacturing industry are not found in the panel data models in Chapter 4 and 5. Chapter 6 shows the positive effects of transshipment of Busan Port on the output of the automobile industry during the period from 2001 to 2010. Hence, we can conclude that the separation of the economic relationship between a container port and its region might occur and the higher rate of transshipment of a container port can reduce the regional effects of the port in the economy from the findings on regional effects of transshipment in Chapter 4 and 5.

From the findings in Chapter 4, 5 and 6, we acknowledge that the development of a container port can positively affect the regional economy and the increasing ratio of transshipment would reduce the overall regional effects of a container port. Hence, the thesis will discuss in the next Chapter the classification of container ports on the basis of the roles of the container ports in shipping and inland transport networks. If we evaluate the regional effects of container ports only from the view of shipping connection, we might lose a deeper understanding of the diverse effects of container ports on the manufacturing industries by period and by region. We may also underestimate the possibility of separation between a container port and its regional economy due to the transshipment activity of the container port.

Container port as a multimodal transport facility combines different transport modes such as shipping, railway, trucking and other logistic services. Although container port locates at a specific region, it can focus its role in a certain transport network. Furthermore, the increasing ratio of transshipment movement in the container liner shipping helps container ports to specialize its catchment of cargoes on shipping rather than inland transport modes. The transshipment container movement in the world records 181 million TEU, sharing 26.4% in 683 million TEU of world container traffic in 2015 (Drewry Maritime Research, 2017a).

The thesis interprets a container port as a transport network and selects container throughput as an indicator of networking and development of a container port in Chapter 4, Chapter 5, and Chapter 6. Container ports in Korea exemplify a positive role to regional manufacturing by handling containers of Korean shippers and foreign shippers in these Chapters. Furthermore, Korean container ports serve transshipment containers from neighbouring countries such as China and Japan. These containers of Korean trade goods and transshipment containers are moved through shipping networks and inland transport networks around a container port. The contents and types of shipping network and inland transport network around a container port will affect the role of container port in a region and a country.

Hence, the examination of characteristics of both shipping network and inland transport network of container ports can enhance our understanding of dynamic interaction between a container port and its regional economy such as manufacturing industries in Korea. Different effects of Korean container ports on manufacturing industries as shown in Chapter 4, Chapter 5, and Chapter 6, heighten the necessity of a new definition of container ports in accordance with the role of container ports in shipping and inland transport networks, and a new evaluation tool of container ports in multimodal transport networks.

7. Classification of Container Ports on the Basis of Network

- focusing on North-East Asia container ports-

7.1 Introduction

In Chapter 4, 5 and 6, the thesis finds that the overall effects of Korean container ports on manufacturing industries are positive, but they are different in each region and in different periods. The effects of Korean container ports on manufacturing industries occur differently in the cases of leather, bag and shoe industry and automobile industry. The transshipment activity of Korean container ports does not affect largely the output of manufacturing industries. Considering these findings, we can see that the role of container ports can be classified on the basis of both shipping and its inland transport networks. If we only consider shipping networks when evaluating the regional effects of container ports, we might fail in counting diversity of container ports in relation to the interaction between a port and the regional economy. The increasing ratio of transshipment in container transport as described in 6.6 of Chapter 6 also reminds us of the necessity of a new approach to the role of container ports in both shipping and inland transport network.

The container ports have not been a major subject in the discussion of port classification. Approaches to port classification can be defined into the three categories in accordance with the standards of each classification: shipping classification, generation classification and functional classification as can be seen in Table 7.1. The *shipping* classification groups ports in terms of hierarchical status within shipping networks (Rimmer 1967; Hayuth, 1978; UNCTAD, 1990; Zeng and Yang, 2002): for example, hub port, deep-sea direct-call port and feeder port (Wang and Slack, 2000; Fremont, 2007). The *generation* classification follows a port's linear development in view of its functional and evolutionary change, for example, from primitive fishing village to fully developed facility such as a global logistics centre (Hoyle, 2000; Ducruet and Lee, 2006). The third classification of ports, that of *functional*, asserts that globalization and regionalization in the world economy promote ports to be developed as transshipment hubs or regional load centers in the global logistics chain (Hayuth, 1981; World Bank, 1999; Robinson, 2002; Notteboom and Rodrigue, 2005; Rodrigue and Notteboom ,2010b), and facilities of trade, supply and logistics (Bichou and Gray, 2005). These classifications are not comprehensive to account for the realistic status of ports in transition between shipping and inland transport networks. The current classifications do not consider simultaneously the changes in shipping and inland transports, the combination of shipping and inland transport networks around a container port, and the emergence of transshipment ports.

Table 7.1: Comparison of port classifications

Definition/items	Intermodal Transport	Shipping network	Inland network	Logistics service	Relationship with region	Definition of shipping line	Basic function
Shipping classification	∆	√	-	-	-	∆	-
Generation classification	∆	-	-	√	√	-	-
Functional classification	√	∆	∆	√	∆	-	-

Note: √ : including, ∆ : partially including or unclear, -: not including.
Source: Author's elaboration.

Even after adding another classification, which explores the spatial development of a port in a city or an urban system (McCalla, 2004; Hayuth, 2007; Wiegmans and Louw, 2011), we find it hard to clarify the classification difference between a general port and a container port, examine the popularity of container system in a port, and note the impacts on a container port from various combinations of shipping and inland transport networks.

The precise classification of a container port enables participants of container transport and policy makers to understand the roles played by container ports and the interaction between container ports and their regions.

Hence, this Chapter aims to clarify the types of shipping and inland transport networks and to define container ports according to these types and their roles in a regional economy. For this purpose, this Chapter divides and defines shipping networks in terms of geographical coverage of each route. This Chapter also groups inland transport networks in accordance with contents of their service and function. Furthermore, the assumption that policy makers can combine shipping network and inland transport network in relation to regional development would yield us a new direction to conceptualize diverse types of container ports.

Chapter 7 is structured as follows. Section 2 introduces new definitions of shipping networks and inland transport networks, and briefly addresses the input data. Section 3 discusses definitions of shipping networks and inland transport networks in some ports of Korea, China, and Japan. In Section 4 we discuss nine types of new classification of container ports, combination of three shipping and three inland transport networks. Section 4 exemplifies types of new classification for 23 container ports in Korea, China, and Japan. In Section 5 we conclude with a discussion of some policy suggestions that may be implemented on the basis of new classification of container ports.

7.2 Definition and data

7.2.1 Definition

From the vantage points of shippers and logistics providers, the container port network consists of a triptych: shipping, port and inland (Rimmer, 1967; Hayuth, 1978; Hayuth 1981; Hilling and Hoyle, 1984; Notteboom, 2009; Rodrigue and Notteboom, 2010a; Nam and Song, 2011). These three components are intrinsically connected. With this idea, this Chapter examines the container port as a core element connected with the shipping network and the inland transport network.

Firstly, shipping networks including lots of shipping routes cover all container ports in the world as foreland of a container port and connect container ports. The categorization of the regions as shown in Table 7.2 follows mainly the definition of regions in the Containerisation International Yearbook by the Informa UK (Informa UK, 2010), which seems to adopt the definition of regions adopted by the liner conferences (Clark ,1989). This Chapter adopts the definition of seven continents: Asia, Africa, North America, South America, Antarctica, Europe, and Australia.

According to the geographical coverage of shipping routes and referring to the geographical definition of an area by liner conferences (Clark, 1989; Informa UK, 2010), the shipping networks can be classified into the three types of hierarchy, a similar hierarchy by Zeng and Yang (2002): *continental, regional and feeder* networks. A continental route in the thesis means a shipping route that connects two or more different regions in different continents in the East/West shipping axis, which was described by Drewry Shipping Consultants (2010).The regions are not the same continent which a container port belongs to (See Fig. 7.1). In continental shipping activity the trend has been to develop mergers, strategic alliances, and joint calling among shipping companies in order to broaden service networks and also to reduce vessel operation costs by calling at fewer ports (Hayuth, 1978; Alix et al. ,1999; Slack, 2004; Imai et al., 2005; Rodrigue and Notteboom, 2010b).

Table 7.2: Definition of continents, regions, and countries in shipping networks

Continents	Regions	Major countries
Africa	North Africa	Algeria, Egypt, Libya, Morocco, South Sudan, Tunisia, Western Sahara, Canary Islands(Spain), Madeira Islands (Portugal)
	Southern Africa	Botswana, Lesotho, Namibia, South Africa, Swaziland (following UN scheme of region)
	East Africa	Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Tanzania, Uganda, Somalia,
	West Africa	Benin, Burkina Faso, Cape Verde, Cote d`Ivoire, The Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo
	Indian Ocean	Madagascar, Mauritius, Reunion (France)
Australia	Australia	Australia, Fiji, Kiribati, New Caledonia, New Zealand, Papua New Guinea, Samoa, Vanuatu,
Europe	Northern Europe	Belgium, Denmark, Estonia, Finland, France (in the Atlantic), Germany, Iceland, Ireland, Latvia, Lithuania, Netherland, Norway, Poland, Russia, Sweden, Switzerland, UK
	Southern Europe	Albania, Bosnia and Herzegovina, Bulgaria, France (in the Mediterranean), Greece, Italy, Moldavia, Montenegro, Portugal, Slovenia, Spain, Turkey
North America	North America –East Coast St Lawrence and Great Lakes	USA (East coast), Canada, Bermuda (Hamilton)
	North America –West Coast and Gulf Coast, Including Hawaiian Islands	USA (West coast), Canada, Mexico
	Central America	Bahama, Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Nicaragua , Panama, Puerto Rico
South America	South America	Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Falkland Islands, French Guiana, Guyana, Paraguay, Peru, Surinam, Uruguay, Venezuela,
Asia	East Asia	Brunei, Cambodia, Hong Kong, Indonesia, Laos, Macau, Malaysia, Philippines, Singapore, Thailand, Vietnam
	North-East Asia	China, Japan, South Korea, Russian Far East North Korea, Taiwan
	Indian subcontinent	Bangladesh, Burma, India, Pakistan, Sri Lanka
	Middle East	Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen

Source: Author's elaboration based on the data of Informa UK (1990-2013).

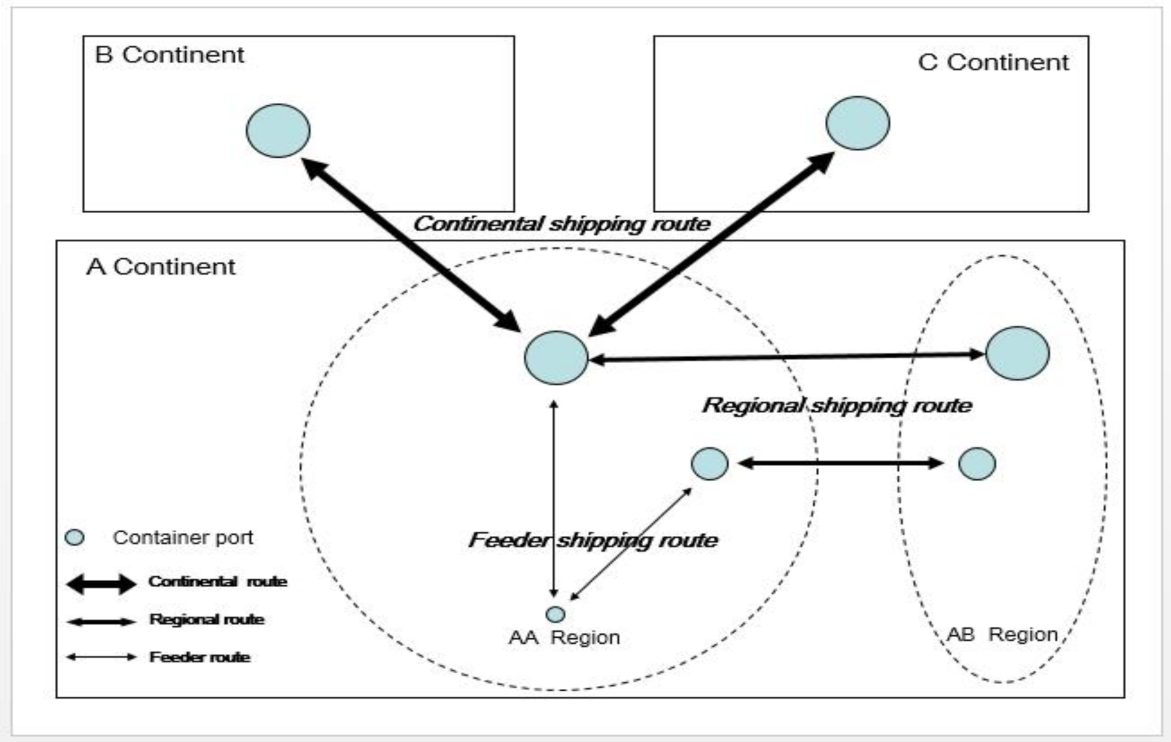

Figure 7.1: Three definitions of shipping networks and routes
Source: Author's elaboration.

A regional route as shown in Figure 7.1 is a shipping route that connects two or more different regions that belong to the same continent (Wang and Slack, 2000). Due to the sustained growth in the shipping trade, larger vessels than the Panamax sized container vessel carrying approximately 4500 twenty-foot equivalent unit (TEU), may now be deployed within the regional shipping routes (Cullinane and Khanna, 2000).

A sub-regional or feeder route is a route that connects two or more different container ports that are in the same region or in the same country as shown in Figure 7.1. The ports mainly in a feeder route tend to connect with other bigger ports in continental and regional shipping routes in order to provide indirectly shippers with continental and regional routes (Wang and Slack, 2000). The feeder shipping routes for transshipment is very changeable, as shown in the shift of feeder shipping in North East Asia after the 1995 Kobe earthquake (Chang, 2000).

Inland transport network of a container port is aimed to serve shippers in hinterlands, forelands and backward areas (Rodrigue and Notteboom, 2010a). In addition, the services which a container port supplies to the shippers and the relationship between a container port and its city or its region are heavily dependent on the types of inland transport networks (Hoyle, 2000; Walter and Poist, 2004; Notteboom and Rodrigue, 2005; Ducruet and Lee, 2006; Hayuth, 2007; Verhetsel and Sel, 2009; Wiegmans and Louw, 2011).

Inland transport networks of a container port can be grouped into three types in accordance with the spatial structure and the available transport modes (Winkler and Seebacher, 2011). The *multifunctional* inland network as shown in Figure 7.2 has an exclusive backward area or integrated logistics facilities alongside the container terminal, and supplies two or more transport connections, for instance railways near or within the container terminal, inland waterway or short sea shipping, and air transport, basically having a road network. The *bi-modal* inland network is a network where container yard or logistics facilities are away from the container terminal and a port supplies one and more transport modes among railways near or within the container terminal, inland waterway or short sea shipping, basically having a road network. The *simple* inland network is a network of haulier service with road networks.

Through the multifunctional inland network, a container port is able to stabilize its inland transport networks, improve punctuality in delivery to and from inland areas, and even shorten the turnaround times of a container vessel through improving effectiveness and productivity in the container port (Hayuth, 1981; Talley, 2002). The suburbanization of a container port is due to the need for larger sites for a container terminal on one hand and also for the improvement of spatial and temporal flexibility of the inland transport (Rodrigue and Notteboom, 2009). The suburbanization can enable a container port to reduce other environmental aspects (Hayuth, 1981).

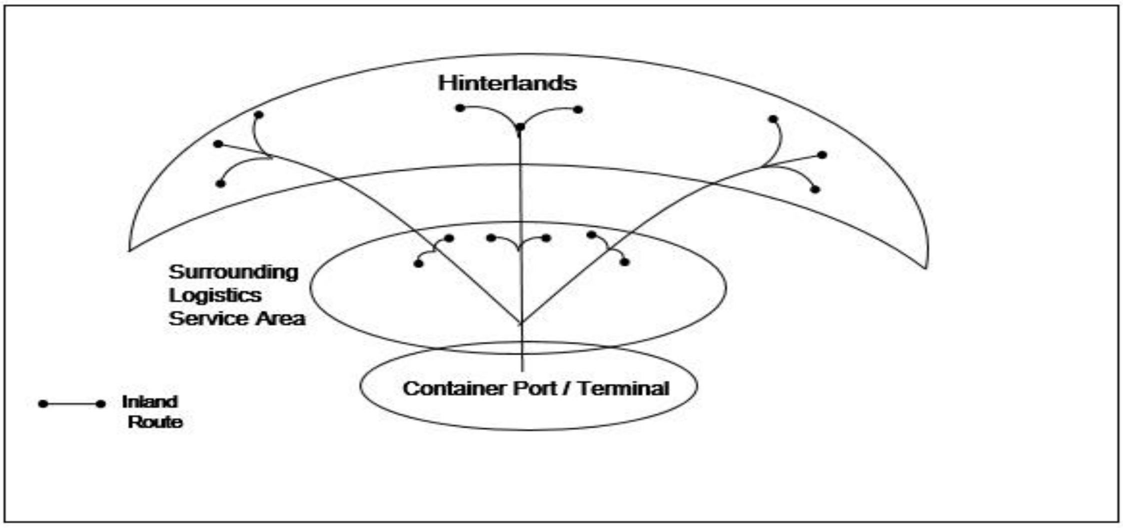

Figure 7.2: Multifunctional inland transport network
Source: Author's elaboration.

The backward area, in which various economic activities are organized by logistics providers, is known as a free trade zone (FTZ) or free economic zone (FEZ), such as at Shanghai and Shenzhen, or as a free zone, logistics park or distripark, such as the distriparks at Rotterdam and Hamburg (Pettit and Beresford 2009). It has different names in accordance with the legal system of each country. Backward areas interface between local and global networks (Slack, 1999; Notteboom and Rodrigue, 2005; Roso et al., 2009).

The interrelationship between shipping and inland transport networks around a container port can be understood as a coordination of price mechanisms (Robinson, 2002; Mclellan, 2006; Van der Horst and Langen, 2008; Fremont and Franc, 2010; Van der Horst and Van der Lugt ,2011). Some consider the interrelationship as an integration of transport modes (Notteboom and Rodrigue, 2005; Song and Panayides, 2008; Panayides and Song, 2009; Roso et al., 2009; Nam and Song, 2011).

We aim here to examine different combinations between port/port terminal and inland transport modes (Van Klink and Van den Berg, 1998; Robinson, 2002; Tan, 2007; Song and Panayides, 2008; Woo et al., 2011). The international trade, policy development of the government as in the case of Singapore (Tan, 2007), and players in transport networks (Van Klink and Van den Berg, 1998; Fowler, 2006; Fremont, 2007) also affect these combinations.

We could identify the variable factors, which dynamically change the contents and the process of combination of shipping and inland transport modes around a container port. The factors are the development of transshipment activity within the container transport (Van Klink and Van den Berg, 1998; Fremont, 2007; Nishimura et al., 2009; Rodrigue and Notteboom, 2009; Rodrigue and Notteboom, 2010b) and various objectives of service providers, customers, and policy makers. Incentives from the public authorities (Fremont and Franc, 2010) and the decasualization of port labour supply of a container port (Levinson, 2006) would be other factor.

A pure transshipment container port similar to the cases of Algeciras port, Spain; Tanjung Pelepas port, Malaysia; and Gioia Tauro port, Italy can serve narrow hinterlands (Fremont, 2007). Conversely, an inland waterway port only with feeder shipping lanes such as Chongqing in China and Frankenbach Terminal in Mainz, Germany may have multifunctional inland transport networks.

7.2.2 Input data

Based on calling schedules of liner shipping companies, shipping networks of a container port can be analysed. Using the shipping route database of container vessels in Containerisation International by Informa UK (Informa UK, 2011), this study defines classifications of world container ports by a higher hierarchical shipping network among the shipping networks which a container port handles. Since the container volume in the East/West axis that includes the transpacific, the transatlantic and the Europe/North-East Asia routes contributes 71% of the container trade in the world in 2009 except the volumes of intra-regional routes (Drewry Shipping Consultants Ltd., 2010), the shipping networks can be classified mainly by the shipping routes in the East/West axis. The shipping routes for container ports in North-East Asia can be divided into three routes in terms of regions shown in Table 7.3. The continental routes connect North-East Asia to Northern Europe, Southern Europe, North America East coast, and North America West coast. The regional routes serve the regions of East Asia, Indian Subcontinent, and the Middle East. The feeder routes refer to the shipping lanes within North-East Asia.

Table 7.3: Three types of shipping routes and regions for North-East Asia container ports

Type	Continental	Regional	Feeder
Regions of shipping route	Northern Europe, Southern Europe, North America East coast, North America West coast	East Asia, Indian Subcontinent, Middle East	North-East Asia

Source: Author's elaboration.

The data on the inland transport network of each port such as an exclusive backward area, logistics facilities, container yard, and inland transport modes are collected from the information of the Ports and Terminals Guidebook (IHS Fairplay, 2010), and the websites of North-East Asia container ports. The guidebook on ports and terminals by IHS Fairplay provides us with detailed inland transport modes of a container port and logistics facilities within and around a container port.

7.3 Shipping and inland transport networks in North-East Asia

7.3.1 Shipping networks in North-East Asia

Prior to 1990, the main trunk route in Asia was comprised of shipping services calling at Singapore, Hong Kong, Busan, and Japanese container ports such as Kobe as shown in Figure 1.2. These ports were connected directly with European and American container ports (Yeo et al. 2008). From the early 1990s, container ports in Korea and Taiwan such as Busan and Kaoshiung could expand feeder routes to smaller ports in the North East Asia region (Chang, 2000). Furthermore, since the late 1990s Chinese container ports have emerged as the core of the shipping market and now handle significant trade volumes in continental shipping routes (Song, 2002; Yap and Lam, 2006).

Table 7.4 identifies the major container ports in North East Asia according to the three definitions of shipping networks. The numbers of continental routes, regional routes, and feeder routes for a container port in North-East Asia mean the number of foreign container ports that directly connect to the container ports under scrutiny as shipping networks.

The container ports in a continental shipping network have continental, regional, and feeder routes; the container ports in regional shipping network handle regional and feeder routes; and the container ports in feeder shipping network serve only sub-regional routes. However, some ports mainly in regional and feeder shipping networks have exceptional continental routes such as Pyeongtaek Port and Masan Port in Korea. Since these two ports cannot operate transshipment containers from other ports and do not have multiple shipping connections with other continents, we define their shipping networks into a lower classification of shipping network. River shipping routes on the

Yangtze to the river ports in China and branch shipping networks of Shanghai Port with Dandong, Haikou, Jiuzhou, and Longkou in China belong to feeder shipping network (Notteboom, 2007; Notteboom, 2012).

Table 7.4: Shipping networks of major container ports in North-East Asia

Port/shipping routes and networks		No. of continental routes				No. of regional routes			No. of sub-regional routes	Types of shipping networks
		NE	SE	NA	SA	EA	ME	IS		
Korea	Busan	40	51	108	35	297	43	49	529	continental
	Gwangyang	16	9	30	1	76	16	23	140	continental
	Incheon	0	0	0	0	42	0	1	73	regional
	Ulsan	0	0	0	0	25	0	7	65	regional
	Pyeongtaek	0	0	6	0	4	0	0	16	regional
	Donghae	0	0	0	0	0	0	0	3	feeder
	Gunsan	0	0	0	0	0	0	0	3	feeder
	Pohang	0	0	0	0	1	0	0	4	regional
	Masan	1	0	0	0	1	0	0	7	regional
China	Shanghai	106	105	116	40	468	97	86	415	continental
	Chiwan	24	34	31	14	112	34	14	59	continental
	Fuzhou	9	3	9	0	21	12	9	6	continental
	Shantou	0	0	0	0	7	0	0	3	regional
	Yingkou	0	0	0	0	0	0	0	2	feeder
	Longkou	0	0	0	0	0	0	0	1	feeder
	Chongqing	0	0	0	0	0	0	0	2	feeder
Japan	Kobe	21	4	40	1	109	15	3	190	continental
	Yokohama	71	5	54	17	135	6	1	228	continental
	Hakata	11	0	1	0	24	1	9	48	continental
	Omaezaki	0	0	0	0	6	0	3	6	regional
	Hiroshima	0	0	0	0	4	0	0	16	regional
	Kanazawa	0	0	0	0	0	0	0	6	feeder
	Kure	0	0	0	0	0	0	0	1	feeder
	Oita	0	0	0	0	0	0	0	4	feeder

Note: 1) NE: Northern Europe, SE: Southern Europe, NA: Northern America, SA: Southern America, EA: East Asia, ME: Middle East; IS: India Subcontinent.
2) Pyungtaek port supplies shippers with continental shipping routes only of North America West Coast.
3) Masan port provides continental and regional service in biweekly schedule.

Source: Author’s elaboration based on the data of Informa UK (2010a).

7.3.2 Inland transport networks in North-East Asia

A container port in a multifunctional inland transport network can be separated from the urban areas, especially downtown areas, but connects to logistics facilities in the city as in the cases of Yangshan Terminal of Shanghai Port and Busan New Port of Busan Port (Park et al., 2006; Seo et al., 2015). Due to severe competition for attracting transshipment containers in North-East Asia, nowadays container ports in the region tend to have multifunctional inland transport networks and supply various logistics services to shippers (Slack, 1999; Song, 2002; Notteboom and Rodrigue, 2005; Levinson, 2006; Rodrigue and Notteboom, 2009).

A bi-modal inland transport network has backward areas near container ports, which act as container yard (CY) and warehouses: for example, Gwangyang Port in Korea and Hakata Port in Japan have small container yards and warehouses (JR Freight Co., 1994; Baird, 1999). Nevertheless, it is the case that a container port, its backward area, and its hinterlands have little economic interaction with each other in the production process through input and output processing, with the exception of a transport connection through container yards and warehouses.

In a simple inland transport network, backward areas are integrated with the hinterlands where a container originates and terminates. Container ports in this network may be domestic feeder ports or regional feeder ports such as Gunsan and Donghae in Korea and they mainly supply loading and unloading services to shippers.

The ports of continental shipping network in North East Asia shown in Table 7.5 can be divided into three types according to the different inland transport networks. For example, ports of multifunctional inland transport networks are Busan in Korea, Shanghai and Fuzhou in China, which have railway networks, air network, diverse short sea shipping networks, active free trade zone (FTZ) or logistics park, and various hinterlands of origin and destination (People's Transport Publication Co., 2000; Park et al., 2006; IHS Fairplay, 2010).

Table 7.5: Types of inland transport networks of major North-East Asia container ports

Port/inland transport modes and networks		Connected transport modes			Logistics facilities: FTZ or logistics park	Types of inland transport network
		International airport	Freight railway	Inland waterway or short sea shipping		
Korea	Busan	√	√	√	√	Mutifunctional
	Gwangyang	-	√	-	√	Bi-modal
	Incheon	√(hub)	-	√	√	Mutifunctional
	Ulsan	-	√	-	√	Bi-modal
	Pyeongtaek	-	-	-	√	Simple
	Donghae	-	-	-	-	Simple
	Gunsan	-	-	-	√ (FEZ)	Simple
	Pohang	-	-	-	√	Simple
	Masan	-	-	-	√	Simple
China	Shanghai	√	√	√	√ (Free trade port area)	Mutifunctional
	Chiwan	√	-	√	√ (Free trade port area)	Mutifunctional
	Fuzhou	√	√	-	√	Mutifunctional
	Shantou	-	√	-	√	Bi-modal
	Yingkou	-	√	-	-	Bi-modal
	Longkou	-	-	-	-	Simple
	Chongqing	√	√	√	√ (Free trade port area)	Mutifunctional
Japan	Kobe	-(charter)	√	-	√ (Economic Special Zone)	Bi-modal
	Yokohama	-	√	-	√ (Industrial zone, commercial zone)	Bi-modal
	Hakata	√	√	-	-	Bi-modal
	Omaezaki	-	-	-	-	Simple
	Hiroshima	√	√	-	-	Bi-modal
	Kanazawa	-	-	-	-	Simple
	Kure	-	√	-	-	Simple
	Oita	- (feeder)	√	-	-	Simple

Source: Author's elaboration based on the data of IHS Fairplay (2010), Japan Port Association (2005), JR Freight Co. (1994), and Ministry of Maritime and Fishery Affairs of Korea (2004).

7.4 Classification of container ports in North-East Asia

7.4.1 Nine types of container ports

According to the status of a container port within shipping networks, container ports can be divided into three types. Though the type 1s in Table 7.6 can stay at the high status of shipping network through continental shipping routes, their status in inland transport network can be classified into the three types by inland transport modes and services. These three classifications are a dominant port with multifunctional inland transport network, a superior port with bi-modal inland transport network, and an intermediary port with a simple inland transport network. Since a container system tends to stress the role of shifting containers, container ports even in the high status of shipping network may have a lower status in inland transport network, as shown in the development of a pure transshipment container port as described by Baird (2006) and Fremont (2007).

Type 2s are situated in the middle status of shipping network by providing shippers regional shipping services such as Intra Asia routes and Mediterranean routes. Due to the regionalization of each economy and enlargement of regional trade, these container ports in the middle status of shipping networks can diversify their inland transport network in accordance with various demands of customers: a versatile port with multifunctional inland transport network, an ordinary port with bi-modal inland transport network, and a developing port with simple inland transport networks.

The type 3s stay in the low status of shipping network only through feeder shipping routes such as the river feeder services on the Yangtze River in China (Notteboom, 2007; Notteboom, 2012), Korea/Japan routes, Korea/China routes, and China coastal routes. Nevertheless, the ports in feeder shipping routes develop three types of inland transport network in order to respond to changes in customer’s demand. The ports of three types include a distribution port with multifunctional inland transport network, an industrial port with bi-modal inland transport network, and a peripheral port with simple inland transport network.

Table 7.6: Nine types of container ports

Inland transport network/Shipping network	Continental network (Type 1s)	Regional network (Type 2s)	Feeder network (Type 3s)
Multifunctional Network	Dominant container port	Versatile container port	Distribution container port
Bi-modal network	Superior container port	Ordinary container port	Industrial container port
Simple network	Intermediary container port	Developing container port	Peripheral container port

Source: Author's elaboration.

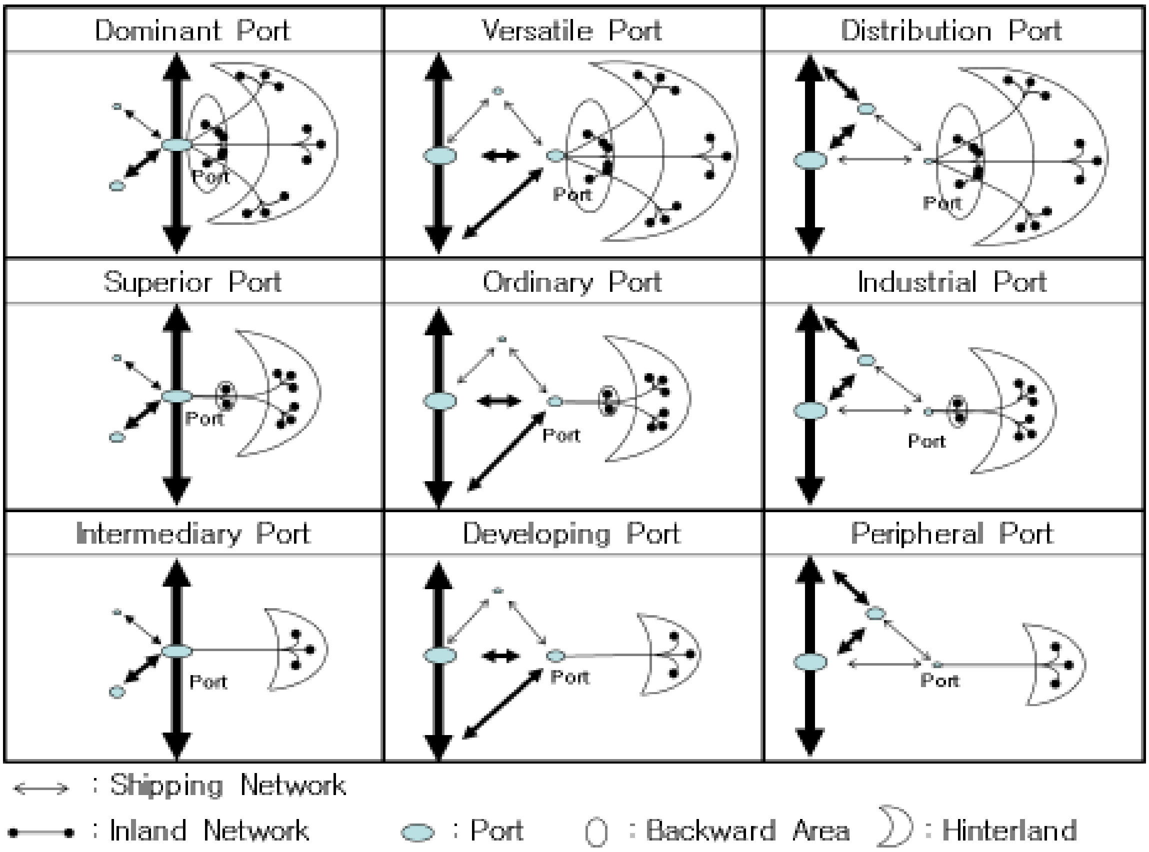

Figure 7.3: Nine types of container ports by combing shipping and inland transport networks
Source: Author's elaboration.

The classification in Figure 7.3 portrays the nine types of container ports, ranging from a *dominant* port in intercontinental shipping network and multifunctional inland transport network on the upper left side, to a *peripheral* port in feeder shipping network and simple inland transport network on the bottom right side. Each type of container port is described in the following sections.

7.4.2 Classification of container ports in North-East Asia

The 23 major container ports in North-East Asia can be classified by nine types of combination by shipping and inland transport networks as shown in Table 7.7. For example, Busan in continental shipping and multifunctional inland transport network belongs to the type of dominant container port; Masan having regional shipping and simple inland transport network is a developing container port.

Table 7.7: Classification of 23 major North-East Asia container ports

Port/networks and types of classification		Types		Type of classification
		Shipping network	Inland transport network	
Korea	Busan	c	M	Dominant
	Gwangyang	c	B	Superior
	Incheon	r	M	Versatile
	Ulsan	r	B	Ordinary
	Pyeongtaek	r	S	Developing
	Donghae	f	S	Peripheral
	Gunsan	f	S	Peripheral
	Pohang	r	S	Developing
	Masan	r	S	Developing
China	Shanghai	c	M	Dominant
	Chiwan	c	M	Dominant
	Fuzhou	c	M	Dominant
	Shantou	r	B	Ordinary
	Dongguan	f	B	Industrial
	Longkou	f	S	Peripheral
	Chongqing	f	M	Distribution
Japan	Kobe	c	B	Superior
	Yokohama	c	B	Superior
	Hakata	c	B	Superior
	Omaezaki	r	S	Developing
	Hiroshima	r	B	Ordinary
	Kanazawa	f	S	Peripheral
	Kure	f	S	Peripheral
	Oita	f	S	Peripheral

Note: shipping networks including c: continental, r: regional, and f: feeder;
inland transport networks including M: multifunctional, B: bi-modal, and S: simple.

Source: Author’s elaboration.

Dominant container ports connect other continental container ports through a global shipping network and a multifunctional inland transport network that gives access to regional markets or mega-markets. Most leading shipping companies and shipping alliances have a calling schedule at dominant ports. As leaders of designing new port systems and technologies, dominant ports can produce their own cargo movement by activating the economy in their backward areas and hinterlands, where diversified value-added services can be supplied to shippers. The backward area of a port is considered as a centre of value-added services (Hayuth, 1978; Wang and Slack, 2000).

The growth and development of dominant ports is exemplified by Shanghai Port as a maritime hub in China. Shanghai Port has demonstrated a continual growth of cargo movement and its function (Eng, 1989; Ministry of Communication of China, 2006). The other cases of dominant ports are Chiwan Port in Southern China, and Busan Port as a hub in North East Asia as shown in Table 7.7. These two ports have a vast Free Trade Zone and logistics facilities around the terminal and diverse short sea shipping routes or river feeder shipping routes with river ports along the Yangtze River (Wang and Slack, 2000; Song, 2002; Park et al., 2006).

Superior container ports have a global shipping network with a bi-modal inland transport network. The ports, Gwangyang in Korea, and Kobe, Yokohama, and Hakata in Japan belong to the superior container port group as listed in Table 7.7. Gwangyang Port is located on the South coast of South Korea. The port was planned to become the second main container port in Korea by the Korea government (IHS Fairplay, 2010). The port has diverse shipping routes and serves shippers with railway and lorry linkages (Ministry of Maritime and Fishery Affairs of Korea, 2004). Kobe Port is located on the coast line of Osaka Bay. Before the 1995 earthquake at Kobe the port was one of the main gateways in North-East Asia, having various feeder routes with Chinese and Korean ports (Chang, 2000).

Intermediary container ports have a global shipping network as well as simple inland transport network to their hinterlands. Since the major throughput of these container ports is transshipment cargo of other container ports, its industrial relations with its backward areas is weak (Baird, 2006; Fremont, 2007). Intermediary ports are generally used exclusively by a few shipping companies. Nevertheless, in the North-East Asia region, the geographical character of locating edges of transpacific routes may hinder the development of an intermediary container port.

Versatile container ports have a regional shipping network but their inland transport network is multifunctional. An example of versatile port is Incheon Port in Korea as shown in Table 7.7, since the port with regional shipping network has good accessibility to large markets.

Incheon Port is located on the Yellow Sea at the mouth of the Han River, approximately 28 km west of the Seoul Metropolitan Area (SMA). The development of the port had been restricted by the Law on Development Management of the Seoul Metropolitan Area enacted in 1982 and the Green Belt until the early 2000s. In 2004 the port opened a new container terminal to provide shippers around SMA with diverse intermodal services such as sea and air intermodal transport, utilizing air cargo transport network at the Incheon International Airport (Ministry of Maritime and Fishery Affairs of Korea, 2004, Park and Medda, 2011).

Ordinary container ports have regional shipping network and bi-modal inland transport network. Ulsan Port in Korea, Shantou Port in China, and Hiroshima Port in Japan in Table 7.7 have rail and road networks, but supply regional shipping network and thus are categorized as an ordinary container port. Ulsan Port located on the East Sea is a major Korean port that handles large amounts of crude oil, petroleum products, containers, and imports raw materials (IHS Fairplay, 2010). The port began serving container vessels in 1992 and opened an exclusive container terminal in 2001 (Ulsan Newport Container Terminal Co., 2011). It connects with its hinterlands by rail and road (IHS Fairplay, 2010).

Developing container ports have regional shipping network and simple inland transport network. Through the shipping network developing container ports can connect with regional container ports and seldom other container ports in other continents. Pyeongtaek Port, Pohang Port and Masan Port in Korea, and Omaezaki Port in Japan represent this type of container port. Omaezaki Port in Table 7.7 is situated on the South coast of Honshu and one of regional ports on Shizuoka prefecture (IHS Fairplay, 2010). It has regional shipping routes connected with hub ports such as the port of Singapore and domestic coastal shipping routes with Japanese main container ports such as Tokyo and Hakata (Japan Port Association, 2005; Informa UK, 2011).

Distribution container ports have branch or feeder routes in the shipping lanes and multifunctional inland transport network. Chongqing Port in China represents this type of container port. Chongqing Port is located in the South East of the Sichuan province on the Yangtze River (Table 7.7). The port acts as distribution center for industrial and farm products in Western China (IHS Fairplay, 2010). The port links river feeders to railways and lorry transports (People’s Transport Publication Co., 2000; Notteboom, 2012). It has vast hinterlands: Yunnan, Sichuan, and Guizhou Province, and Chongqing City (People’s Transport Publication Co., 2000).

Industrial container ports have branch or feeder shipping routes in the shipping lanes and bi-modal inland transport network. Dongguan Port in China in Table 7.7 is an example of industrial container port, because its backward area is composed of different industrial complexes scattered across a wide area such as complexes of steel and electronics manufacturing. Dongguan Port has feeder shipping routes with Northeast Asian ports and domestic short sea shipping lanes.

Peripheral container ports have branch or feeder shipping routes and simple inland transport network. Through branch and feeder routes, peripheral container ports connect indirectly with the intercontinental shipping service. Examples of peripheral container ports are Donghae and Gunsan in Korea, Longkou in China, and Kanazawa, Kure, and Oita in Japan as shown in Table 7.7. Their economic relationship with their hinterlands is restricted to the transport of cargo. The spatial separation of a container port from a city or region might not occur at the peripheral container port.

The classification of container ports by conceptualizing nine types of combination of shipping and inland transport networks may be a basic tool to understand both the diversity of the function and the typical standardization within networks of container ports and their development.

7.5 Conclusions

Major technological advances in transport such as car, train, aeroplane, and information and communication innovations have on the one hand weakened the traditional function of ports as centres for culture, trade, and finance interchange. On the other hand, technology has induced and developed different types of shipping networks and inland transport networks around container ports. A container port might strategically choose its facilities and equipment, and then lure shipping and inland transport networks in order to optimize its operations and positions in the global supply chains and regional economies. This process is developed by supplying various types of shipping, inland transport and service networks that range from intercontinental shipping network with multifunctional inland transport network to feeder shipping network with simple inland transport network.

This Chapter has discussed here how the classification of container ports in the view of shipping hierarchy, generation and function is a useful approach to analyse and clarify changes in the port industry and to better understand the areas around ports. However, as this Chapter has highlighted, there are limitations to the existing classifications due to the necessity to analyse the economic relationships between ports and regions, examine diverse types of container ports, define integrated networks of shipping and inland transport around ports, and address the homogenization of management and operations of a container port. A new classification of container ports underlines various implications of the economic functions of a container terminal and its backward areas while considering the shipping networks and inland transport networks. Especially as the major functions and roles of a container terminal in the region may differ from one another, as global logistics chains are closely connected due to information and communication technologies and new organizations of global logistics supply chains. Various concepts of a container port may be possible, and precise conceptualization is required to plan new container terminals in order to exploit its benefits and economic returns to stakeholders.

This Chapter has defined a new classification of container ports on the basis of shipping and inland transport networks, which can provide us with a foundation to analyse the relationships between a container port and its region, among ports, airports and inland terminals, and between ports' activities and information technology. The new classification helps us to understand the coexistence of various types of container ports and the individual development strategies of ports. This new classification examines different functions and impacts of container ports on regional economies to which they belong, and in accordance with their networks. The nine types of container ports, from the container port in direct intercontinental shipping network and multifunctional inland transport network, to the container port in feeder shipping network and simple inland transport network, summarize the main characteristics of container ports or container terminals. New definition of container ports adopts both shipping hierarchical and functional approaches, and separates shipping and inland transport networks into three types in order to highlight the functional relationship between a container port and its region. A container port can therefore handle different transport networks between sea and inland areas through combination of networks according to decisions of shipping companies, shippers and logistics providers. This classification will give a new perspective to port operators and decision makers to know exactly the interrelationships between the various actors, and to better plan the future development of a container port.

Using the categorization of container port in this Chapter, the thesis will explore the indexation of port hub status in both shipping and inland transport networks in Chapter 8.

8. Hub Status and Indexation of Container Ports

8.1 Introduction

Hierarchical classification of container ports in Chapter 7 enables us to categorize each container port in accordance with status within shipping and inland transport networks. This Chapter introduces a hub index, which could indicate the hierarchical status of container ports.

The revolutionary concept of the internationally standardized iron box has instigated continuously dynamic changes at nodes and links across transport networks (Levinson, 2006). The standardization of containers nowadays affects the design and shape of vessels, trucks, and railway flatcars. Some transport facilities such as ports, truck terminals, railway stations, and warehouses have fully adapted their designs and structures to accommodate the container. Improvements in the safety and accountability of transport through the use of the container to move cargo from origin to destination currently promote intermodal, multimodal and integrated services by combining different transport modes in a single liability.

In addition, the enlargement of container ships has continued steadily since the 1960s. The largest container vessel is now a ship of over 18,000 Twenty-foot equivalent units (TEUs), about eighteen times larger than the largest container vessel of the early 1960s (Imai et al., 2005; Veldman et al., 2011). Larger vessels tend to limit their calling ports in order to save turnaround time and voyage time, which has resulted in the development of hub and spoke networks (Hayuth, 1978; Slack, 2004; Lin and Tsai, 2014). Furthermore, myriad technical and network changes related to container transport have also impacted firm behaviour, regional economies, and trade patterns. Given these important changes, the analysis of the interrelation between a container port and its region must account for innovation in container transport as well as complexity in the interaction between a port and its region.

In order to accurately evaluate the role of a container port in the regional economy, a measurement of hub status of a container port would be useful. This thesis aims to test a hub index for container ports to appraise their status in terms of shipping networks, inland transport networks, and various logistics services. The index uses key factors of port operations and activities, and measures the relationship between ports and their transport networks. The index will complement existing indexes for container ports, such as the Liner Shipping Connectivity Index (UNCTAD, 2005), the port accessibility index to world shipping networks (Cullinane and Wang, 2009), and the assessment index of hub status (Low et al., 2009). In this Chapter we will test the hub index with a dataset on three Korean container ports (Busan, Gwangyang and Incheon) and two European container ports (Rotterdam, the Netherlands and Felixstowe, the U.K.).

The present Chapter is arranged as follows. Section 2 reviews the context of the hub-and-spoke network. The Section also reconsiders the role of the hub in the container transport system and within intermodal transport. Section 3 explains the collection of the panel data from the Korean ports, Busan, Gwangyang, and Incheon, and European ports, Rotterdam and Felixstowe, and describes different scales for calculating a hub index. In a regression analysis of cargo throughput, in Section 4 we test the suitability of the scale of sub-indexes from the hub index in addition to other variables of port inputs, such as the handling capacity of containers, length of berth, and area of container yard at a port. Section 5 suggests diverse types of hub index and illustrates the trend of hub indexes for the five container ports. Section 6 restates our findings and draws this Chapter to a close.

8.2 Context: hub-and-spoke

8.2.1 Hub-and-spoke network

In order to best use their limited capacity, transport companies among other things, have forged strategic alliances, shared services and concentrated services on just a few nodes (Alderighi et al., 2007). The hub-and-spoke network is a prime example. It consists of a few hubs that serve as connecting or central nodes and many feeders linked to other nodes, mainly through the hub. This point-to-point network offers direct links to other nodes and radiates from a hub (Flemming and Hayuth, 1994; Wang and Slack, 2000; Low et al., 2009; Nishimura et al., 2009; Roso et al., 2009; Gelareh and Nickel, 2011).

Since the introduction of standardized containers in shipping, the hub-and-spoke network has changed the geographical range of shipping services, from a region or a nation, to the global scale. It now promotes transshipment activity at ports proximal to the intersection of main sea routes or where the main flows of container traffic enter into feeder routes (Talley, 2002). Furthermore, the continuous enlargement of container vessels themselves has induced the division of container ports into hub and feeder ports (Yeo, 2010; Nam and Song, 2011).

Even though the hub-and-spoke network has stratified container ports into a few hubs and numerous feeder ports, the status of a container port can nevertheless be diversified from a peripheral to a global hub port in accordance with its status in shipping networks, inland transport networks, and logistics chains provided around the port. Nowadays, a container port in a feeder network, such as Chongqing Port in China, can be a main player in inland transport network and logistics chain (Trip and Bontekoning, 2002; Notteboom, 2012). A pure transshipment port in main shipping routes similar to Tanjung Pelepas port in Malaysia may function well with tiny inland transport network (Zeng and Yang, 2002; Nishimura et al., 2009; Petering, 2009). In addition, containerization of the transport system and the deregulation of transport industries have fostered intermodal transport of containers and diversification of shipping networks, inland transport networks, and logistics chains around container ports (Talley, 2002; Nam and Song, 2011).

8.2.2 Literature on the measurement of hub status

The standard measurement of hub status for ports, airports, and railway stations mainly assumes that the hub in a transport network plays the role of a connecting junction between transport routes in the same transport modes. Major measurements and indices also tend to focus on the evaluation of hub status of nodes within the same transport mode, which could be shipping network, air transport network, railway network, or personal communication network (Freeman et al., 1991; Burghouwt and Wit, 2005; Low et al., 2009). When analysts attempt to measure the accessibility of a port or a transport node, they try to gauge the connection of a port or a transport node to its hinterlands (Bergqvist and Tornberg, 2008; Bok, 2009; Thill and Lim, 2010). The accessibility evaluation is useful, for example, when assessing connectivity or centrality of single transport mode. However, it is insufficient in the assessment of intermodal transport and in cases where a port has multiple transport networks in close proximity.

We find therefore that the accessibility evaluation cannot be used as an integral indicator for the hub status of a container port in the same way as the port accessibility index suggested by Cullinane and Wang (2009) can be used to assess a single transport mode. Hence, if a node functions as a multiple role player, such as a container port in intermodal transport, a measurement and index can be more effective when considering and assessing the intermodal roles of a hub port.

8.3 Methodology of indexation

8.3.1 Collection of panel data

The 21-year panel data period covers the years from 1991 to 2011. Our main sources of data include the Containerisation International Yearbook (Informa U.K., 1993-2013), Korean government, port authorities (Port of Rotterdam, 2013), port operators, maritime magazines and consulting companies. Outputs of a container port consist of general cargo and containers. The throughput of general cargo at a port is comprised of the movement of all cargo, excluding crude oil, ores, and coal. The measurement unit of general cargo is tonnage, and the measurement unit of containers is the twenty-foot equivalent unit (TEU).

The inputs of a container port are composed of three major elements: handling capacity of container (represented by the number of quay cranes and their mechanical characteristics), length of berths, and area of container yards. We use a measurement of the handling capacity of a container port, which can be counted by multiplication the number of quay cranes and their yearly mechanical capacity (Rankine, 2003; Park and Medda, 2014).

8.3.2 Port classification sub-index

Furthermore, in this Chapter we develop a sub-index of port classification through taking the mean of two scales of shipping and inland transport networks.

The thesis adopts three categories of shipping networks: continental, regional, and feeder networks. A scale of shipping networks can be weighted by the slot size of a representative container ship in each shipping network, as shown in Table 8.1: Post-Panamax for a continental network; Panamax for a regional network; and around average size of world container ships for a feeder shipping network. These sizes of container ships and their slot capacity represent the network potential of a container port (Lam, 2011). We use this size ship as a relative scale of each shipping network.

Table 8.1: Shipping networks and representative ships

Item/Shipping network	Continental network	Regional network	Feeder network	Total
Type of a representative ship	Post-Panamax	Panamax	Average of container ships	
Slot capacity	8000TEU	4000 TEU	2700 TEU	14700
Scale of shipping network	8000/14700	4000/14700	2700/14700	1

Source: Author's elaboration based data of Drewry Shipping Consultants Ltd. (2010).

Therefore, if a container port has three shipping networks, it can serve three representative sizes of container ships. We can evaluate the scale of the shipping networks of each container port, as in Table 8.2.

Table 8.2: Shipping networks and scale of each network

Port/Item	Continental network	Regional network	Feeder network	Shipping network scale
A port	√	√	√	14700/14700
B port	√	√		(8000+4000)/14700
…	…	…	…	…
P port			√	2700/14700

Source: Author's elaboration based data of Drewry Shipping Consultants Ltd. (2010).

Usually inland transport modes can be placed into four categories: truck, rail, barge and/or short sea shipping, and distripark (Ottjes et al. 2006). We add an additional mode: international airport for cargo transport. We put the same weight on each inland transport mode as shown in Table 8.3, similarly to the cases of evaluation of transport infrastructure and services of each country by the World Economic Forum and the case of logistics performance evaluation by the World Bank (World Bank, 2010; World Economic Forum, 2010a; World Economic Forum, 2010b). In Table 8.3 we can observe different types of inland transport modes around a container port and their scales.

Table 8.3: Inland transport networks and scale of each network

Port/Item	Road	Freight railway	Inland waterway and/or short sea shipping	Logistics facilities: FTZ and/or logistics park	Inter -national airport	Inland network scale
Scale	0.2	0.2	0.2	0.2	0.2	
A port	√	√	√	√	√	1
B port	√	√	√	√		0.8
C port	√	√	√			0.6
…	…	…	…	…	…	…
P port	√	…				0.2

Source: Author's elaboration

By taking an arithmetic mean of the shipping network scale and the inland transport network scale, we are able to calculate the sub-index of port classification (PCI) as shown in Equation 8.1. The assumption here is that each network of shipping and inland transport can equally affect the economic role of a container port, and that their range of economic effects will be decided by different components of shipping and inland transport networks.

$$PCI_p = (SS_p + IS_p)/2 \quad (8.1)$$

Where,

PCI_p: classification sub-index of port p, $0 < PCI_p \leq 1$,

SS_p: shipping network scale of port p, $0 < SS_p \leq 1$,

IS_p: inland transport network scale of port p, $0 < IS_p \leq 1$.

8.3.3 Port capacity sub-index

Since the handling capacity of container ports can represent the status and efficiency of ports very well, two indexes are developed in this thesis: one is calculated by absolute value of capacity and the other by relative value of capacity. We use the container throughput record of the highest ranking port worldwide in the previous year and the optimum utilization ratio of mechanical handling capacity of a container port.

The port capacity sub-index 1 of a container port is as follows,

$PSI1_p$ = *Mechanical handling capacity of port p / Estimated optimum capacity of the port in world rank one* (8.2)

Where,

Estimated optimum capacity of the port in world rank one in year t-1

= (1/0.781) x (container throughput of the port in world rank one)

0.781: the utilization ratio of mechanical capacity of container ports (Park and Medda, 2014)

We cap the upper value of the first type of port capacity sub-index at 1.

Therefore,

$0 < PSI1_p \leq 1$

While considering the wide range of expansion and shrinkage of handling capacity of container ports, we can develop the relative value of changes of handling capacity. We assume that the capacity of the present year in extreme expansion becomes twice that of the previous year capacity as demonstrated in Equation 8.3; and the capacity of the present year in extreme shrinkage becomes half of the previous year capacity. The thesis develops the second type of port capacity sub-index as in the following.

$PSI2_p = (0.5) / c$ (8.3)

$c = (Capacity_{t-1} / Capacity_t)$

Where,

$Capacity_t$: handling capacity of present year t.

The value of c ranges from 0.5 in the case of extreme expansion, to 2 in the case of extreme shrinkage of capacity.

Therefore,

$1/4 \leq PSI2_p \leq 1$

We can assess the changes of the handling capacity of container ports by PSI2: PSI2 in expansion of capacity exceeds 0.5; and PSI2 in shrinkage of capacity is below 0.5.

A hub index of a container port is formulated by combining two sub-indexes: port classification sub-index and port capacity sub-index. Port classification sub-index is based on the shipping, inland transport networks, and logistics services of a container port. Port capacity is counted as an indicator for mechanical handling capacity or status of a container port.

8.3.4 Two dependent variables

Two methods are developed in terms of dependent variables. Method Ⅰ seeks suitable variables to impact the throughput of general cargo during the study period 1991 to 2011. Method Ⅱ focuses on container throughput during the same period. In the analysis of panel data, the thesis excludes the data of the port of Gwangyang in order to collect our 21-year dataset, 1991 to 2011. The port of Gwangyang started to operate its container terminal in 1998.

8.4 Panel data models and regression results

8.4.1 Panel data

Chapter 8 analyses the relationship between a dependent variable and independent variables. Chapter 8 uses tonnage of general cargo or container throughput of the ports as a dependent variable and port-classification sub-index, container handling capacity, length of berths, and area of container yards of the ports as independent variables.

Table 8.4: Summary of the panel data of the four container ports

Variable	Obs	Mean	Std. Dev.	Min	Max
Ttlg (thousand ton)	84	112,557	72,295	16,126	258,331
Cth (thousand TEU)	84	4,541	3,544	113	12,963
Class	84	0.71	0.18	0.43	1
Cca (thousand TEU)	84	9,304	7,028	789	30,297
Length (m)	84	6,951	5,199	493	18,091
Area (thousand m^2)	84	2,442	1,971	28	6,933

Note: ttlg: throughput of general cargo; cth: container throughput; class: classification sub-index; cca: container handling capacity; length: length of berths; area: area of container yards

Source: Author's elaboration based on the data of Informa UK (1990-2013).

In the panel data of ports of Busan, Incheon, Rotterdam and Felixstowe, tonnage of general cargo ranges from 16 million ton up to 258 million ton; container throughput of the ports from 113 thousand TEU to 13 million TEU; port-classification sub-index from 0.43 to 1; and container handling capacity of the ports from 789 thousand TEU to 30 million TEU as listed in Table 8.4. The length of berths in the ports records 493 m in minimum and 18 km in maximum. The area of container yards ranges from 28 thousand m^2 to 6.9 million m^2.

8.4.2 Linear regression model

In the regression analysis as shown in Equation 8.4, dependent variables are tonnage of general cargoes or container throughput. Independent variables include classification sub-index, handling capacity of containers, length of berths, and area of container yards (Yeo, 2010). The thesis tests the effects of independent variables on a dependent variable while using linear regression method. The thesis assumes that the independent variables affect dependent variable such as tonnage of general cargoes or container throughput of a container port as shown in Equation 8.4.

$$\text{Throughput} = F(\text{PCI}, \text{Capacity}, \text{Length}, \text{Area}) \quad (8.4)$$

Where,

Throughput: tonnage of general cargoes or container throughput of a container port,

PCI: classification sub-index of a container port,

Capacity: mechanical handling capacity of containers of a container port,

Length: length of berths of a container port,

Area: area of container yards of a container port.

Specifically, the thesis uses a simple linear regression model as in the following Equation 8.5. A simple linear regression model may reveal a correlation between dependent variable, tonnage of general cargoes or container throughput of a container port and independent variables.

$$\text{Throughput} = a_1 + a_2\,\text{PCI} + a_3\,\text{Capacity} + a_4\,\text{Length} + a_5\,\text{Area} \quad (8.5)$$

The thesis develops Equation 8.6 in format of panel data model with disturbance term, e_{it}.

$$\text{Throughput}_{it} = a_1 + a_2\,\text{PCI}_{it} + a_3\,\text{Capacity}_{it} + a_4\,\text{Length}_{it} + a_5\,\text{Area}_{it} + \varepsilon_{it} \quad (8.6)$$

Where,

Throughput_{it} : tonnage of general cargoes or container throughput at port i in year t.

Independent variables in Equation 8.6 contain the terms of i and t, which mean specific port i and year t.

8.4.3 Tests of suitability of models

Since Chapter 8 uses the panel data of Busan Port, Incheon Port, Rotterdam Port and Felixstowe Port, the thesis adopts panel data models among linear regression models as described in 4.3.3 in Chapter 4. Chapter 8 also follows the similar tests of Chapter 4 mainly on disturbance term in Equation 8.6.

Before estimating the coefficients of the variables in Equation 8.6, the thesis first conducts Hausman test, a significance test of the random effects model. Then, the thesis examines the autocorrelation in panel data and tests heteroscedasticity of the disturbance term in Equation 8.6. These tests are shown in Table 8.5.

Table 8.5: Summary of searching for suitable models and suitability tests

Test/Method	Ⅰ	Ⅱ
Variables	Dependent: total throughput Independent: classification sub-index, handling capacity, length of berth, area of container yard	Dependent: container throughput Independent: classification sub-index, handling capacity, length of berth, area of container yard
Hausman test	$\chi^2(3) = 9.01$ Prob. > chi² = 0.029	$\chi^2(3) = 0.42$ Prob. > chi² = 0.516
Wooldridge test for autocorrelation in panel data	F(1, 3)=15.86 Prob.> F = 0.028	F(1, 3)=153.24 Prob.> F = 0.001
Likelihood-ratio test of homoscedasticity	$\chi^2(3) = 65.29$ Prob. > chi² = 0.000	$\chi^2(3) = 77.23$ Prob. > chi² = 0.000

Note: Prob. is the abbreviation of probability.
Source: Author's elaboration based on the data of Informa UK (1990-2013).

In the first method, which chooses total cargo throughput as a dependent variable, the result of Hausman test tells that unobserved individual effect is correlated with independent variables. Hence, fixed effects model has better efficiency than random effects model. Since the panel data of Busan, Incheon, Rotterdam and Felixstowe include the characteristics of time-series, the disturbance term might contain the autocorrelation of disturbance in the groups in the panel data (Greene, 2008). The result of the Wooldridge test shows autocorrelation of panel. In the test of homoscedasticity of disturbance, the thesis finds the heteroscedasticity, which violates an important assumption of homoscedasticity of disturbance in a classical linear regression model as described in 4.3.3 of Chapter 4 (Gujarati, 2003).

In the second method that chooses container throughput as dependent variable, the result of Hausman test tells that unobserved individual effect is uncorrelated with independent variables. Hence, random effects model has better efficiency than fixed effects model. In the second method, the thesis also finds the autocorrelation of disturbance in the groups in the panel and the heteroscedasticity of disturbance.

Since the first method and the second method show difference in efficiency of fixed effects model and random effects model, the thesis chooses both models in order to compare regression results. Then the autocorrelation of disturbance in the groups in the panel and the heteroscedasticity of disturbance suggest the methods of generalized least squares (GLS) estimator as described in 4.3.3 of Chapter 4. In panel data models of fixed effects model, random effects model, and methods of generalized least squares (GLS) estimator, the thesis finds that the coefficient of classification of sub-index is too large. Hence, the thesis takes additionally Box-Cox transformation (Maddala, 2004). In addition, tonnage of general cargoes and container throughput of a container port tend to be affected by the values of previous year due to port choice behavior of shippers and shipping companies, and existing inland transport networks or transport facilities such as railway and dry ports (Monios, 2011; Van den Berg and De Langen, 2011). Hence, the thesis utilizes the tonnage of general cargoes or container throughput of a container port of previous year as another independent variable in a dynamic model.

8.4.4 Model description

The thesis uses fixed effects model (Model 8.1.1 and Model 8.1.7), fixed effects model with autocorrelation (Model 8.1.2 and Model 8.1.8), random effects model with autocorrelation (Model 8.1.3 and Model 8.1.9), methods of GLS estimator (Model 8.1.4 and Model 8.1.10), estimation by Box-Cox transformation (Model 8.1.5 and Model 8.1.11), and dynamic model (Model 8.1.6 and Model 8.1.12) as shown in Table 8.6. Since the coefficients of length of berth and area of container yard in fixed effects model (Model 8.1.1 and Model 8.1.7) are inconclusive, the thesis excludes the two independent variables in other models. The thesis adds lagged values of general cargo or container throughput in the dynamic models, Model 8.1.6 and Model 8.1.12.

Table 8.6: Regression results of general cargo and container throughputs

Variable / Model	Dependent: General Cargo						Dependent: Container Throughput					
	M-8.1.1	M--8.1.2	M--8.1.3	M--8.1.4	M--8.1.5	M--8.1.6	M--8.1.7	M--8.1.8	M--8.1.9	M--8.1.10	M--8.1.11	M--8.1.12
Intercept	-152453	143858	4433	-847	87285	-	-2449	-8092	-1695	-4726	29	-
Classification sub-index	273543*** (5.1)	42073 (0.74)	115949** (2.14)	84125*** (2.85)	167343	13974 (0.5)	5262 (1.20)	14859*** (2.80)	5845** (2.03)	8318*** (7.05)	19.84	7959*** (5.59)
Handling capacity of containers	5.82*** (4.1)	1.45** (2.3)	2.54*** (4.0)	6.08*** (10.5)	2.6e-06	0.47 (0.9)	0.36*** (3.10)	0.19*** (3.01)	0.24*** (3.7)	0.32*** (10.9)	0.01	0.27*** (10.5)
Length	-1.56 (-0.9)						-0.18 (-1.27)					
Area	10.8 (1.5)						0.46 (0.77)					
$Throughput_{t-1}$						0.93*** (17.0)						0.27*** (6.28)
Sample Size	84	80	84	84	84	76	84	80	84	84	84	76
R^2 F	0.55 62.1	0.56 3.0	0.55 -	- -	λ=2.45*** θ=0.95***	-	0.73 20.9	0.84 10.1	0.50 -	- -	λ=0.69*** θ=0.29***	- -
Wald χ^2			22.3 Prob.> χ^2 = 0.000	188.0 Prob. > χ^2 = 0.000		-			36.90 Prob. > χ^2 = 0.000	395 Prob.>χ^2 = 0.000		-

Note: 1) * significant at 10% level; ** significant at 5% level; *** significant at 1% level

2) M-8.1.1 & M-8.1.7: Fixed Effects Model; M-8.1.2 & M-8.1.8: Fixed Effects Model with auto-correlation; M-8.1.3 & M-8.1.9: Random Effects Model with auto-correlation; M-8.1.4 & M-8.1.10: GLS Model; M-8.1.5 & M-8.1.11: Box-cox transformation; and M-8.1.6 & M-8.1.12: Dynamic Model.

Source: Author’s elaboration based on the data of Informa UK (1990-2013).

8.4.5 Results of regression models

After inputting the panel data of Busan Port, Incheon Port, Rotterdam Port and Felixstowe Port into STATA (Statistics Data Analysis) 14 program, Chapter 8 first checks the suitability of regression models including panel models. Then Chapter 8 selects regression models and uses STATA 14 program to get coefficients of independent variables.

In the analysis of tonnage of general cargoes in Busan Port, Incheon Port, Rotterdam Port and Felixstowe Port, fixed effects model (Model 8.1.1), random effects model with auto-correlation (Model 8.1.3), and method of GLS model (Model 8.1.4) have better explanatory power of independent variable of port classification sub-index. These models show higher t-statistics than other models, Model 8.1.2, Model 8.1.5, and Model 8.1.6. Port classification sub-index in dynamic model (Model 8.1.6) has inconclusive coefficient. This inconclusive coefficient of port classification sub-index seems to be caused by the various effects of different variables on the fluctuation of general cargo in a port.

In the analysis of container throughout in Busan Port, Incheon Port, Rotterdam Port and Felixstowe Port, fixed effects model with autocorrelation (Model 8.1.8), random effects model with auto-correlation (Model 8.1.9), method of GLS model (Model 8.1.10), and dynamic model (Model 8.1.12) have positive and statistically significant coefficients of port classification sub-index. Port classification sub-indexes in fixed effects model (Model 8.1.7) and estimation by Box-Cox transformation (Model 8.1.11) have inconclusive coefficients.

Linear regression models explaining container throughput from 1991 to 2011 show positive effects of classification sub-index and handling capacity of containers on container throughput, as presented in Model 8.1.8, Model 8.1.9, Model 8.1.10, and Model 8.1.12. However, the possible positive correlation among handling capacity of containers, length of quays, and the area of container yards seems to give a similar value of estimators of handling capacity in Models of 8.1.7, 8.1.9, and 8.1.12. Model 8.1.11 with Box-cox transformation lessens the sensitivity of coefficient of classification sub-index. The dynamic model, Model 8.1.12, also has statistically a significant coefficient of lagged container throughput at 1 percent significance level, as shown in the regression of general cargo.

From the main results of the regression we can conclude that the models having the classification sub-index and the lagged variable of container throughput or handling capacity of containers have better explanatory power in the analysis of container throughout in Busan Port, Incheon Port, Rotterdam Port and Felixstowe Port. The thesis will utilize the main results of the regression in finding proper indexation of hub status of a container port.

8.5 Indexation and analysis

8.5.1 Indexation of hub status of a container port

While we combine the Port Classification Sub-index and two Port Capacity Sub-indexes: Port Capacity Sub-index 1 and 2, we are able to measure the hub status of a container port. The sub-indexes of port capacity are evaluated in Equation 8.2 and Equation 8.3. Sometimes researchers adopt the method of moving average weight of elements to make an index less sensitive to the specific year, and in order to widen the available information, as suggested by the World Economic Forum (World Economic Forum, 2010a). The thesis calculates the moving averages of *Port Capacity Sub-index 1* and *Port Capacity Sub-index 2* as in Equation 8.7.

That is,

Moving Average of $X_t = \{(0.6 \times X_t) + (0.4 \times X_{t-1})\}$ (8.7)

Where,

X_t: *Port Capacity Sub-index 1 or Port Capacity Sub-index 2 in year t.*

Nine types of hub index are shown in Table 8.7, which combine differently *Port Classification Sub-index* and *Port Capacity Sub-index 1* in Equation 8.2. The types of WS3-1 and WS4-1 in Table 8.7 use the present sub-indexes of port classification and port capacity; types of WS3-2 and WS 4-2 mix the present Port Classification Sub-index and the moving average of Port Capacity Sub-index 1. Types of WSP-1 and WSP-2 in Table 8.7 adopt the average values of Port Classification Sub-index and Port Capacity Sub-index 1 of five years from the fourth previous year to the present. Types of WSL-1, WSL-2 and WSL-3 in Table 8.7 use the lagged values of Port Classification Sub-index and Port Capacity Sub-index 1. All hub indexes range over 0 to 1 and higher hub index means higher status of shipping network and inland transport networks.

Table 8.7: Hub Indexes of container ports by Port Capacity Sub-index 1

Index		Type	Content	Index range
Hub Index : $\sqrt{(\mathbf{a} \times \mathbf{b})}$		WS3-1		0 < Index ≤ 1
		WS3-2	b: moving average of Port Capacity Sub-index 1	
Hub index: $\sqrt{\frac{(\mathbf{a}+\mathbf{b})}{\mathbf{2}}}$		WS4-1		
		WS4-2	b: moving average of Port Capacity Sub-index 1	
Hub index	$\sqrt{(\bar{\mathbf{a}} \times \bar{\mathbf{b}})}$	WSP-1	$\bar{\mathbf{a}}$: average of classification sub-indexes from 4th previous year to year t, $\bar{\mathbf{b}}$: average of Port Capacity Sub-indexes from 4th previous year to year t.	
	$\sqrt{\frac{(\bar{\mathbf{a}} + \bar{\mathbf{b}})}{\mathbf{2}}}$	WSP-2		
Hub index	$(a_{t-1}+b_{t-1})/2$	WSL-1		
	$\sqrt{(\mathbf{a_{t-1}} \times \mathbf{b_{t-1}})}$	WSL-2		
	$\sqrt{\frac{(\mathbf{a_{t-1}} + \mathbf{b_{t-1}})}{\mathbf{2}}}$	WSL-3		

Note: a: Port Classification Sub-index; b: Port Capacity Sub-index 1,
$\bar{\mathbf{a}} = (a_{t-4} + a_{t-3} + a_{t-2} + a_{t-1} + a_t)/5$,
a_{t-n}: n^{th} previous year's Port Classification Sub-index,
$\bar{\mathbf{b}} = (b_{t-4} + b_{t-3} + b_{t-2} + b_{t-1} + b_t)/5$,
b_{t-n}: n^{th} previous year's Port Capacity Sub-index 1.
Source: Author's elaboration.

Table 8.8: Hub Indexes of container ports by Port Capacity Sub-index 2

Index		Type	Content	Index range
Hub Index : $\sqrt{(\mathbf{a} \times \mathbf{b2})}$		CS3-1		0 < Index ≤ 1
		CS3-2	b2: moving average of Port Capacity Sub-index 2	
Hub index: $\sqrt{\frac{(\mathbf{a}+\mathbf{b2})}{\mathbf{2}}}$		CS4-1		
		CS4-2	b2: moving average of Port Capacity Sub-index 2	
Hub index	$\sqrt{(\bar{\mathbf{a}} \times \overline{\mathbf{b2}})}$	CSP-1	$\bar{\mathbf{a}}$: average of classification sub-indexes from 4th previous year to year t $\bar{\mathbf{b}}$: average of Port Capacity Sub-indexes from 4th previous year to year t.	
	$\sqrt{\frac{(\bar{\mathbf{a}} + \overline{\mathbf{b2}})}{\mathbf{2}}}$	CSP-2		
Hub index	$(a_{t-1}+b2_{t-1})/2$	CSL-1		
	$\sqrt{(\mathbf{a_{t-1}} \times \mathbf{b2_{t-1}})}$	CSL-2		
	$\sqrt{\frac{(\mathbf{a_{t-1}} + \mathbf{b2_{t-1}})}{\mathbf{2}}}$	CSL-3		

Note: a: Port Classification Sub-index; b2: Port Capacity Sub-index 2
$\bar{\mathbf{a}} = (a_{t-4} + a_{t-3} + a_{t-2} + a_{t-1} + a_t)/5$
a_{t-n}: n^{th} previous year's Port Classification Sub-index

$\overline{\mathbf{b2}} = (b2_{t-4} + b2_{t-3} + b2_{t-2} + b2_{t-1} + b2_t)\ /5$

$b2_{t-n}$: n^{th} previous year's Port Capacity Sub-index 2

Source: Author's elaboration.

Table 8.8 lists nine types of hub indexes combining differently *Port Classification Sub-index* and *Port Capacity Sub-index 2* in Equation 8.3. Table 8.8 illustrates a similar calculation method as shown in Table 8.7

8.5.2 Case analysis of five container ports

Next in our case analysis we test different types of hub index, and select and exemplify the three indexes in the superiority of correlation with outputs, total general cargo throughput, and container throughput in Busan Port, Incheon Port, Rotterdam Port and Felixstowe Port (Table 8.9). While all hub indexes show a positive correlation with the throughput of general cargo and throughput of containers in the three Korean ports, only three indexes, CSL-1, CSL-2, and CSL-3, demonstrate tiny positive correlation coefficients with the throughput of general cargo in Rotterdam. The other indexes illustrate negative correlation coefficients with the throughput of general cargo in Rotterdam and in Felixstowe, as shown in Table 8.9. The indexes of CS3-1, CS3-2, CS4-1, CS4-2, CSP-1, CSP-2, CSL-1, CSL-2 and CSL-3 show weak positive correlation coefficients with the throughput of containers in Felixstowe Port.

We select and examine three hub indexes at each port: WS3-2, WSP-2, and CS4-2 listed in Figure 8.1, which have a relatively higher mean value of correlation coefficients with container throughputs of the five container ports. For example, Busan Port has upgraded its position from a gateway port in Korea to a hub port in North East Asia through the uninterrupted expansion of its shipping and inland transport networks, and the increase of its container handling capacity. Therefore, the indexes of hub status of Busan Port show a cyclical change in accordance with the development of container terminals and changes in the handling capacity of containers, as depicted in Figure 8.1.

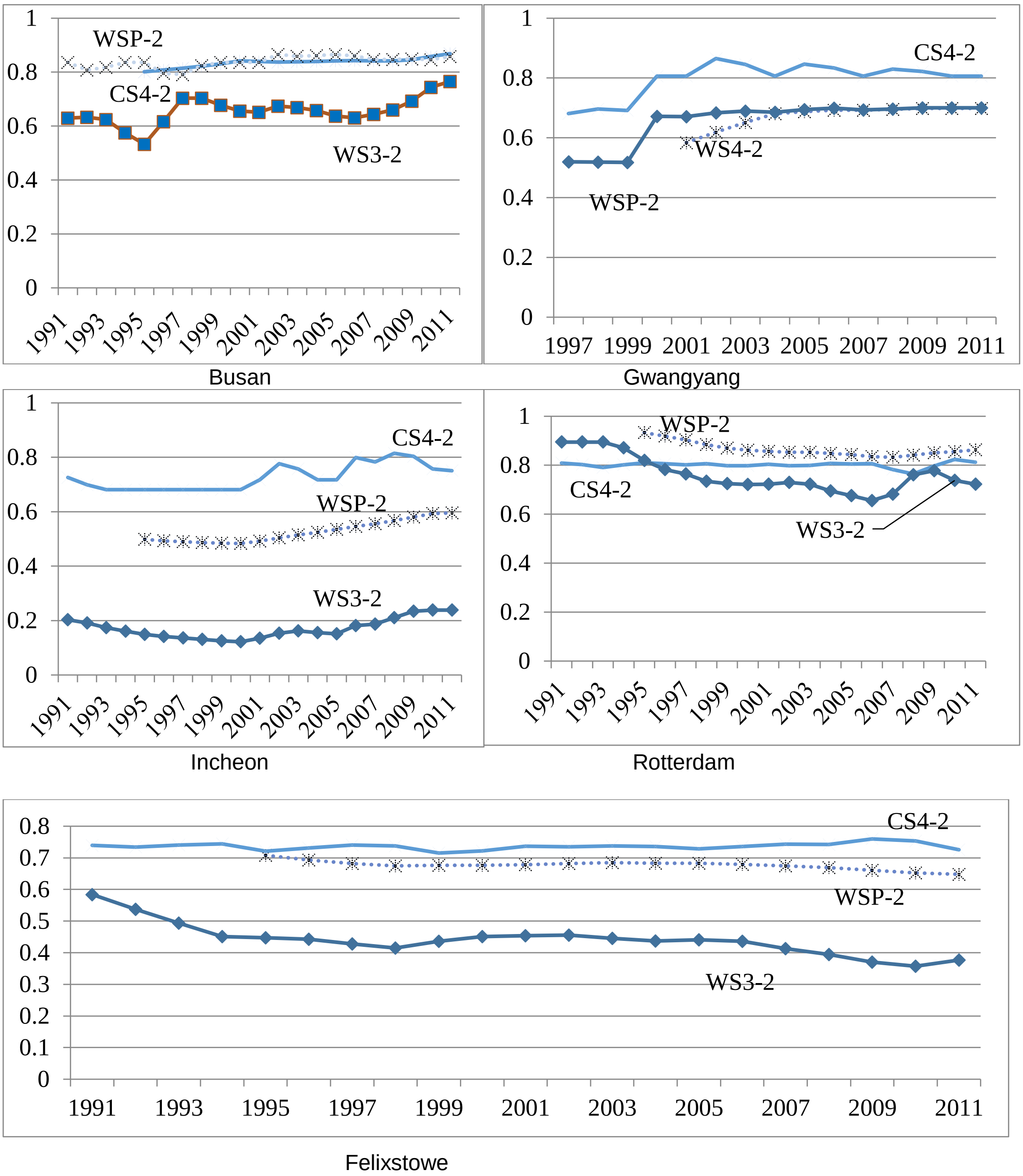

Figure 8.1: Hub indexes of the five container ports

Source: Author's elaboration based on the data of Informa UK (1990-2013).

8.6 Conclusions

This Chapter has investigated the essential roles of container ports in cargo transport networks and carried out an analysis of the fundamental factors and inputs of hub ports. The literature on the measurement of hub status for ports is scarce and does not focus on the different transport networks; papers tend not to consider shipping, inland and logistic services simultaneously, but instead focus mainly on shipping services.

After examining the relationships among outputs and inputs of a container port and valid inputs, which vary the throughputs of general cargo and containers in panel data models, this Chapter has set out to develop a port hub index to evaluate the hub status of container ports. The findings reported here demonstrate that the indexes taking lagged variables and period values have more explanatory power and show high correlation coefficients with the throughput of a container port.

In the case analysis of the five container ports as shown in Figure 8.1, we have observed that each container port has specific characteristics and style of operation. Busan Port expanded its container facilities swiftly and widely in the early 1990s, and later faced a short recession around 1998 when the Korean economy endured a drop in its foreign exchange market. Busan Port nevertheless recovered well from the recession and proceeded to sustain and enlarge its role as a hub. With regard to Gwangyang Port, the port hub index of Gwangyang Port in CS4-2 in Figure 8.1 began to fall gradually after 2005, showing excess capacity compared with its cargo throughput. It became clear that the port would need to develop an innovative strategy to catch shippers in Northeast Asia, especially shippers from China who had been gradually induced to use emerging Chinese container ports. Incheon Port currently also faces a deficiency of container throughput. The two European ports show relatively stable trends in their indexes in Figure 8.1, indicating a steady but slow growth in container throughput in Europe; dull competition and entry barriers for newcomer port may be impacting factors in the European case.

Table 8.9: Correlation coefficients tables between Hub Indexes and indicators of port activity of the five container ports

Item/port/indexes		WS3-1	WS3-2	WS4-1	WS4-2	WSP-1	WSP-2	WSL-1	WSL-2	WSL-3	C3-1	C3-2	CS4-1	CS4-2	CSP-1	CSP-2	CSL-1	CSL-2	CSL-3
Ttl GC	Bs	0.58	0.58	0.72	0.74	0.65	0.86	0.67	0.49	0.67	0.38	0.44	0.60	0.67	0.74	0.88	0.55	0.30	0.54
	Gw	0.74	0.77	0.60	0.61	0.77	0.65	0.67	0.79	0.66	0.31	0.77	0.37	0.41	0.27	0.35	0.46	0.43	0.48
	In	0.44	0.38	0.76	0.75	0.65	0.82	0.71	0.24	0.70	0.61	0.66	0.61	0.66	0.80	0.81	0.50	0.52	0.50
	Rot	-0.46	-0.50	-0.46	-0.50	-0.57	-0.57	-0.54	-0.54	-0.54	-0.05	-0.02	-0.03	-0.01	-0.68	-0.68	0.03	0.01	0.02
	Fel	-0.54	-0.63	-0.56	-0.65	-0.16	-0.17	-0.72	-0.70	-0.72	-0.25	-0.29	-0.25	-0.29	-0.28	-0.28	-0.13	-0.14	-0.13
	Mean	0.15	0.12	0.21	0.19	0.27	0.32	0.16	0.05	0.15	0.20	0.31	0.26	0.29	0.17	0.22	0.28	0.22	0.28
Con	Bs	0.65	0.66	0.77	0.80	0.76	0.92	0.72	0.57	0.72	0.39	0.42	0.59	0.64	0.63	0.79	0.49	0.25	0.49
	Gw	0.94	0.96	0.85	0.86	0.96	0.88	0.89	0.94	0.89	0.58	0.96	0.64	0.72	0.60	0.66	0.73	0.70	0.75
	In	0.67	0.63	0.91	0.91	0.78	0.97	0.89	0.49	0.88	0.69	0.78	0.69	0.78	0.95	0.95	0.65	0.67	0.66
	Rot	-0.62	-0.67	-0.62	-0.67	-0.70	-0.70	-0.70	-0.71	-0.71	-0.12	-0.11	-0.11	-0.10	-0.64	-0.64	-0.02	-0.04	-0.03
	Fel	-0.77	-0.81	-0.77	-0.81	-0.86	-0.86	-0.81	-0.82	-0.81	0.06	0.14	0.06	0.15	0.53	0.53	0.18	0.16	0.17
	Mean	0.17	0.15	0.23	0.22	0.19	0.24	0.20	0.09	0.19	0.32	0.44	0.37	0.44	0.41	0.46	0.41	0.35	0.41
Length of berths	Bs	0.84	0.84	0.89	0.89	0.75	0.84	0.77	0.67	0.76	0.18	0.11	0.35	0.33	0.18	0.42	0.20	-0.03	0.20
	Gw	0.82	0.84	0.64	0.64	0.89	0.78	0.73	0.85	0.72	0.38	0.84	0.43	0.48	0.48	0.54	0.56	0.54	0.57
	In	0.78	0.75	0.97	0.97	0.78	0.97	0.93	0.62	0.93	0.68	0.82	0.69	0.82	0.97	0.97	0.74	0.76	0.75
	Rot	0.80	0.83	0.80	0.83	0.32	0.32	0.82	0.82	0.82	0.22	0.14	0.22	0.15	-0.53	-0.53	-0.03	-0.05	-0.04
	Fel	-0.22	-0.32	-0.25	-0.34	0.18	0.18	-0.44	-0.42	-0.44	-0.46	-0.52	-0.46	-0.52	-0.45	-0.45	-0.22	-0.21	-0.21
	Mean	0.60	0.59	0.61	0.60	0.58	0.62	0.56	0.51	0.56	0.20	0.28	0.24	0.25	0.13	0.19	0.25	0.20	0.26
Area of Cys	Bs	0.84	0.83	0.88	0.87	0.75	0.82	0.76	0.67	0.75	0.16	0.09	0.32	0.29	0.14	0.37	0.17	-0.05	0.17
	Gw	0.74	0.76	0.56	0.56	0.83	0.69	0.64	0.77	0.63	0.31	0.76	0.35	0.39	0.37	0.43	0.46	0.44	0.47
	In	0.83	0.82	0.85	0.86	0.89	0.92	0.88	0.75	0.87	0.50	0.65	0.51	0.65	0.87	0.87	0.66	0.67	0.66
	Rot	-0.17	-0.23	-0.17	-0.23	-0.51	-0.51	-0.30	-0.30	-0.30	-0.09	-0.15	-0.08	-0.14	-0.81	-0.81	-0.15	-0.17	-0.16
	Fel	-0.02	-0.05	-0.03	-0.07	0.14	0.12	-0.11	-0.08	-0.10	0.09	-0.09	0.08	-0.09	-0.33	-0.33	-0.30	-0.29	-0.29
	Mean	0.44	0.43	0.42	0.40	0.42	0.41	0.37	0.36	0.37	0.19	0.25	0.24	0.22	0.05	0.11	0.17	0.12	0.17

Note: Ttl Gc: Throughput of general cargo; Container: Throughput of containers; Cys: Container yards; Bs: Busan Port; Gw: Gwangyang Port; In: Incheon Port; Rot: Rotterdam Port; Fel: Felixstowe Port; Mean: Mean values of indexes of the five ports.

Source: Author's elaboration based on the data of Informa UK (1990-2013).

9. Conclusions and Policy Implication

9.1 Overview of findings

The Korean economy has demonstrated rapid growth and a structural change since the 1960s from an underdeveloped country based on the agricultural industry to a developed country with global brand recognition in many industries. Since the Korea Peninsula is divided into the two parts by the demilitarized zone (DMZ), Republic of Korea (South Korea) depends almost exclusively on shipping for transporting raw materials, parts, components, and goods of export and import. Shipping and ports are a lifeline to the Korean economy. In relation to its hinterlands and the wider regional economy, a container port in Korea contributes to facilitating trade of manufacturers, the main customer of a container port. Hence, the examination of the effects of Korean container ports on manufacturing industries is important to enhance our knowledge on the economic relationship between a port and its region.

In the regional panel dataset of all Korean manufacturing industries and port activities in Chapter 4, the thesis first finds that the regional effects of Busan Port on manufacturing industries in Korea are positive. These results are proven to be robust where the thesis replaces the container throughput of Busan Port with the cargo tonnage inside containers of Busan Port as shown in Table 4.4. The thesis finds positive moderating effects between the container throughput of Busan Port and intermediates, and between the container throughput of Busan Port and wages (Table 4.6). The results imply that the increased activity of Busan container port enhances the positive effects of intermediates and labour inputs on the output of Korean manufacturers.

The thesis notices that the regional effects of container ports vary in accordance with temporal changes and regions. The first period from 1991 to 1998 demonstrates the positive coefficients of container throughput of Busan Port and road (Table 4.7). Nevertheless, the effects of container throughput of Busan Port on the outputs of Korean manufacturing industries are inconclusive in the second period of 1999-2011. When dividing the examined regions into two regional groups, we observe that the regions with a big port, Busan and Incheon, show a negative coefficient of the container throughput of Busan Port on outputs of Korean manufacturing industries (Table 4.7). On the contrary, the development of container ports positively affects the output of regional manufacturing industries in other regions. The regions without a big port have the benefits of improvement of accessibility to global markets in accordance with the development of Korean container ports.

We find also that transshipment activity of Korean container ports does not affect overall output of Korean manufacturing industries in the port cities and other regions as shown in Table 4.8. Hence, the economic interaction between a container port and its regional economy can be weakened in correlation with the increase of transshipment movement in container throughput of a container port.

In the case analysis of the leather, bag and shoe industry, we find in the panel data models that an increase of throughput in Korean ports positively affects the output of the industry from 1992 to 2010 as shown in Table 5.5. The implication here is that Korean ports played a positive role in the development of the leather, bag and shoe industry and the business clustering. Second, if we divide the examined period into two, an increase of port throughput negatively affects the output from 1992 to 2002 and positively from 2003 to 2010 (Table 5.5). The negative effects of the increase of port throughput imply disaggregation of existing clusters in proportion to a decreasing ratio of exports. Third, the positive effects of port throughput from 2003 to 2010 signal that the effects of container ports work in both directions of cargoes: inbound and outbound. Fourth, we find negative effects in the group of regions without a larger port, both during the whole period and in the period from 1992 to 2002 (Table 5.9). The regions without a larger port are affected negatively as the industry transformed from an exporting to an importing industry. Fifth, the negative effect of port throughput in the enduring panel datasets from 1992 to 2010 implies that the enduring establishments experienced negative effects in accordance with growing imports. Lastly, we find that the transshipment activity of Korean container ports does not affect the output of the leather, bag and shoe industry in Korea (Table 5.11).

The relationship between container ports and the automobile industry in Korea shows some diversity between different periods and regions. Generally, the effects of container ports on the output of the automobile industry are positive (Table 6.5). This is confirmed by the robustness test, which replaces container throughput with cargo tonnage inside containers (Table 6.5). We find that the positive effects occur in a similar value in the two periods: the first from 1992 to 2000 and the second from 2001 to 2010 (Table 6.6). The panel data models in the Chapter 6 demonstrate positive effects of transshipment activity of container ports on the output of the automobile industry (Table 6.8). When dividing the examined 15 regions into the two sub-regions: the regions with a big port or a big container port and other regions. The regions with a big port demonstrate positive effect of the container port on output of the automobile industry but the other regions show inconclusive effects (Table 6.7). In the examination of the effects of container ports at each of the 15 regions, we observe a similar result (Table 6.9). The positive effects are observed in the two port cities, Busan and Incheon, and neighbouring regions of Incheon.

While adopting the findings of the diverse relationship between a container port and manufacturing industries, and observing economic separation between the transshipment activity of a container port and regional manufacturing industries in Korea, the thesis defines a new classification of container ports based on shipping and inland transport networks. The new classification of container ports can provide us with a foundation to analyse relationships between a container port and its region. This new classification examines different functions and impacts of container ports on regional economies to which they belong, and in accordance with their networks. The new definition of container ports adopts shipping, hierarchical and functional approaches, and separates shipping and inland transport networks respectively into three types in order to highlight the economic relationship between a container port and its region. The nine types of container ports classification, from the container port in direct intercontinental shipping network and multifunctional inland transport network, to the container port in feeder shipping network and simple inland transport network, summarize the main characteristics of container ports or container terminals. The thesis develops and suggests hub indexes by combining differently two sub-indexes of port classification and handling capacity of containers of a container port.

9.2 Limitations

The thesis has a number of limitations. Firstly, the time limitation of data restricts the examination of container ports only from the 1990s. The panel data extension adding the 1980s will improve the quality of new findings and the detail of analysis. Secondly, detailed responses from manufacturers about the impacts of port development on individual establishments of manufacturing industries would add useful information to the thesis. Thirdly, a comparison with other types of industries such as service industries or transport services could provide deeper insights into the relationship between port development and manufacturing industries. Fourthly, we think that the spatial weight of transport costs or spatial weight regression studies also should be carried out. The thesis chooses clear panel data models rather than spatial regression models in examining the effects of container ports on manufacturing industries in order to compare the results of different cases of each manufacturing industry. Fifthly, the thesis would have benefitted from using panel data of freight rates of container shipping routes to identify which factors influence the direction of trade in the global market, as discussed by Krugman (1980) and Behrens and Picard (2011). Lastly, a demographic approach of manufacturing industries as shown in Table 5.10 of Chapter 5 in the case of leather, bag and shoe industry will enrich our analysis on the interaction between a container port and regional economy.

9.3 Policy recommendations

9.3.1 Container ports and regional economy

The main results of the thesis suggest some implications for policy makers. First, a container port can have a diverse effect on different manufacturing industries in accordance with its specific characteristics of the shipping networks and the inland transport networks. Since we find an economic separation between transshipment activity of a container port and regional manufacturing industries in Korea, a higher status of a container port in shipping might not necessarily bring the same status in inland transport network and enhance regional economic effects of the port. A policy maker needs to understand the separation phenomenon between shipping and inland transport networks. Second, it is necessary for policy makers to assess separately the effects of port development on regional industries, in particular manufacturing industries. Since the aggregated regional effects presented by analysis on aggregated variables such as regional gross domestic product (RGDP) and analysis by Input-Output Table tend to present policy makers with an indicator of optimistic feasibility, policy makers might underestimate the severe competition between foreign competitors and domestic players. Third, the role of ports, especially hub status of container ports, is influenced by changes of global trade and manufacturing industries. In Korea Busan Port as the main hub port in Korea played a gateway for exports of the industries until the early 2000s. Other container ports such as Gwangyang Port and Incheon Port have increased their importance in handling containers since the early 2000s. Hence, a balanced policy on port development between Busan Port and other regional ports could reduce the logistics costs of shippers. Fourth, if a policy maker evaluates the regional effects of container ports only from the view of shipping networks, the policy maker might lose a deeper understanding of diverse roles of container ports on regional economy. A region accommodating a kind of pure transshipment container port can have less connection to regional economy than a region with a port of general cargo.

9.3.2 Hub port and transshipment

The transshipment activity in the Korean case does not have an overall effect on regional manufacturing industries. Hence the increasing ratio of transshipment containers in a hub port may weaken the regional economic effects of the port. If a hub port tries to add other logistics services and provides shippers for transshipment containers with a new business model in the port, the port can produce additional employment and new industries in the region. Busan Port 's increase in its catching portion of transshipment containers from neighbouring countries demonstrated a vulnerability of its status in the shipping network in 2016 when shipping businesses of Korea were crippled by the failure of major companies such as Hanjin Shipping. Since two main Korean ports are aiming at becoming transshipment hubs and are exposed to the fluctuation of container movement in shipping routes, policy makers should consider finding alternatives, in search for a more sustainable business model in Busan Port and Gwangyang Port.

9.4 Future work

From the limitation statement of the thesis in Chapter 9, the thesis can suggest a few future studies in the area of a container port and the regional economy. First, the expansion of time limitation of panel data would give us a fruitful understanding of the interaction between port development and the regional economy. Second, a detailed analysis on individual establishments of manufacturing industries, which includes demographic information, will enable us to test the diverse aspects of the interaction between port development and the regional economy. Third, an examination of the interaction between a container port and the regional transportation sector will deepen our knowledge on an economic role of ports in the regional economy. In Chapter 2, the thesis finds that a few Korean regions among the 16 identified regions illustrate a structural change in the regional production such as a decline in the share of the transportation sector in regional production as in the case of Busan. Fourth, the data on inland transport costs of containers will enrich our analysis on the interaction between port development and the regional economy. Building a panel data including freight rates of container shipping routes might progress our examination on the specialization and diversification of regional industry in the era of globalisation further.

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