UNIVERSITY OF SOUTHAMPTON

FACULTY OF ENGINEERING AND PHYSICAL SCIENCES

Civil, Maritime and Environmental Engineering Unit

AN EMPIRICAL ANALYSIS OF THE ECONOMIC IMPACT OF MAJOR PORTS ON CITIES, SOUTH KOREA

by

JONGJOON SONG

Thesis for the Degree of Doctor of Philosophy

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ABSTRACT

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The changes in port-related activities have been successfully recognised by the key words in recent port studies such as a ‘node’ of a transport network, an ‘integrated component’ in a transport service, and a ‘central place’ in global logistics. Especially, the spatial enlargement of the ports to their hinterlands is generally agreed to occur in practice by connecting discrete port activities with global supply chains. These connections result in various changes in different aspects such as economic impacts, the port community, port governance etc. Port impact studies (PISs) have contributed to understanding the economic impacts of ports both at the national level and at the regional level. However, the PISs have been depending mainly on Input Output (IO) analysis and hence the PISs have methodological constraints that limit the evaluation of the economic impacts of the intensification of functional integration and port regionalisation.

To fill the research gap, this study implements an empirical analysis by following three different steps. Firstly, at the level of a port, this study scrutinises the development path, the interaction with the city and the status in the national port system by applying various qualitative and quantitative methods. Secondly, at the level of a sector in a regional economy, the gross value-added (GVA) per worker of transportation and the four sub-sectors (air, land, water and supporting activities) in transportation are examined by applying the shift-share analysis which has a powerful advantage to partitioning all changes to several effects from regional economy and national one in the relationship between both of them. Lastly, at the level of a regional economy, this study estimates the contributions of the ports to the regional economies by applying an econometric analysis that builds on previous studies.

In conclusion, this study suggests the significant implication that the intensification of functional integration and port regionalisation is likely to enlarge the disparity between the port cities in the sight of the impacts of the ports on its regional economies. This implication is supported mainly by the two different approaches. On one hand, this study shows that individual port cities have quite different transportation sectors in terms of the GVA per worker and the sectoral proportion of transportation in the regional economies by applying the shift-share analysis. In particular, the ports of Busan and Incheon, where containerized freight makes up a high proportion of traffic, make a greater contribution to their regional economies. The originality of this thesis rests in showing if the suggestions in the port studies take place in practice by applying the shift-share analysis and if this methodology is useful in examining the structural changes of four sub-sectors in transportation for the first time. On the other hand, this study implies that the economic impact of individual ports is quite different according to the size of port traffic, the cargo composition and the spatial boundary of the users etc. by applying the econometric analyses, including the sub-group analysis, by region. It implies that significant bias in the PISs can result from the incorrect application of the methodologies such as the IO analysis of using the national IO tables and the econometric analysis of estimating a coefficient for the whole country.

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Declaration of Authorship

I, JONGJOON SONG,

declare that this thesis entitled

An Empirical Analysis of the Economic Impacts of Major Ports on Cities, South Korea

and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission.

Signed:

Date:

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List of Abbreviations

ADB	Asian Development Bank
BLUE	Best Linear Unbiased Estimators
BPA	Busan Port Authority
CBD	Central Business District
CE	Competitive Effect
CY	Container Yard
ECOS	Economic Statistics System of the Bank of Korea
FE	Fixed Effect Model
GBP	Great Britain Pound
GE	Growth Effect
GIS	Geographic Information System
GLS	Generalized Least Square
GNP	Gross National Product
GRDP	Gross Regional Domestic Product
GTO	Global Terminal Operator
GVA	Gross Value-added
IBRD	International Bank for Reconstruction and Development
ICD	Inland Container Depot
ICT	Information and Communication Technology
IM	Industrial Mix
IMF	International Monetary Fund
IO	Input-output
IPA	Incheon Port Authority
KMPA	Korea Maritime and Port Agency
KOSIS	Korea Statistics Information System
KOTI	Korea Transportation Institute
KPHA	Korea Port and Habour Association
KRW	Korean Won
KTDB	Korea Transport Database
LM test	Lagrangian Multipliers test
LQ	Location Quotient
MDL	Military Demarcation Line
MLTM	Ministry of Land, Transport and Maritime Affairs
MOF	Ministry of Oceans and Fisheries
MOLIT	Ministry of Land, Infrastructure and Transport

MOMAF	Ministry of Maritime Affairs and Fisheries
NIZ	National Industrial Zone
ODCY	Off-dock Container Yard
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
PA	Port Authority
PIS	Port Impact Study
POLS	Pooled Ordinary Least Square
POSCO	Pohang Steel Corporation
PPP	Public Private Partnership
R&D	Research and Development
RE	Random Effect Model
RT	Revenue Tonne
SBL	Stand-by Loan
SIC	Standard Industry Classification
SNU	Seoul National University
SPIDC	Shipping and Port Information Data Centre
SRF	Supplemental Reserve Facility
TEU	Twenty-foot Equivalent Unit
TFP	Total Factor Productivity
TG	Total Growth
TMG	Taaffe, Morrill and Gould
UPA	Ulsan Port Authority
VIF	Variance Inflation Factor
WB	World Bank
WBPRTK	World Bank Port Reform Toolkit
WLS	Weighted Least Square
YGPA	Yeosu Gwangyang Port Authority

Chapter 1 Introduction

1.1 Backgrounds

The more the trade and interaction between nations increase, the more the role of ports is diversified. Fundamentally, seaports still play an important role according for more than 90% of trade volumes (Weisbrod, 2011). Secondly, the ports have contributed to the economic and cultural development of the city and even the adjacent regions as the bridge to connect between land and sea (Ng and Ducruet, 2014). Furthermore, the ports carry out successfully a significant role as an access channel for the waves of globalization (Ducruet et al., 2015). This diversification is basically implemented 'in the relation with various factors from surroundings', as mentioned by Hilling and Hoyle (1984). Especially, the technological and structural changes in the global economy and transport networks may be on the first line as the key factors of the diversification (Monios and Wilmsmeier, 2012a). Focused on transportation, it is agreed that a critical factor of the changes is the intensification both of functional integration at the level of a corporation and of competition among the supply chains (Robinson, 2002).[1] These changes driven by the mega-carriers and/or the global forwarders have influenced the functional role of the ports directly. On the other hand, the appearance of the influential actors may be another significant factor to derive the changes in the port community and the port governance (Robinson, 2002, Notteboom and Rodrigue, 2005, Olivier and Slack, 2006).

In the sight of functional roles, the changes in practice have been successfully recognised over time by the keywords in the port studies such as a 'node' of a transport network (Hayuth, 1981), an 'integrated component' in a transport network (UNCTAD, 1992), a 'central place' in global logistics (Bichou and Gray, 2004) and even 'port-centric logistics' (Mangan et al., 2008). On the other hand, some researchers focus on the spatial enlargement and integration between port districts and their hinterlands by connecting various services in the transport networks or the global supply chains (Notteboom and Rodrigue, 2005, Monios and Wilmsmeier, 2012a). These changes have been caused by various factors; for example, globalisation, logistical integration, and intensified competition among the global logistics chains (Monios and Wilmsmeier, 2012b). However, it is clear that the role of the ports in literature is getting connected with the transport networks and embedded in the supply chains among a number of regions (Pettit and Beresford, 2009).

With respect to the spatial aspect, the land where the ports are located is both 'space' which can be used for the various economic activities and 'place' which a number of stakeholders take part in the

[1] He suggests that various discrete but related activities: for example, shipping line, stevedore, freight forwarder, trucking, and depot, are getting integrated and performed within an individual firm or across a number of firms in the supply chains in order to optimise the supply chain management with some economic effects such as economies of scale, of scope and of density.

port activities (Robinson, 2002, Hoyle, 1989, Hayuth, 1982b). In the line of the former, Hayuth (1982b) proposed the port-city interface focusing on the features of the ports as the spatial system in the port city. As well, Hoyle (1989) expanded the concept, based on a geographical line or an area in transition between the port district and the urban zone, to an interactive economic system or an integration area in terms of transportation. Since then, various research suggest the separation between the port and the city by applying various aspects such as separating from the city over time (Hoyle, 1989), reflecting the structural changes in a regional economy (Norcliffe et al., 1996) and maximising the value of the waterfront (Ducruet et al., 2013). Meanwhile, some researchers argue that the pattern with regard to the interface should be understood in the different point of views such as the port life cycle (Charlier, 1992, Ducruet and Lee, 2006), renewal of the port-city links (Hoyle, 2000b) and urban planning perspective (Wiegmans and Louw, 2011).

On the other hand, as the ‘place’, the ports have been recognised to have the community made up of a variety of stakeholders, who have different interests and sources of influence: for example, terminal operators, port labour, end users of port, local environmental groups, local residents, local government and national government (De Langen, 2006). In recent decades, the port community has encountered the rapid changes in terms of both the relationship among the participants and the level of the conflict severity among them (Notteboom et al., 2015). Especially, as the functional roles of the ports have enlarged and diversified, the role and status of the port-related economic actors have been getting greater (Robinson, 2002): for example, several port logistics complexes have been developed under the lead of the multi-national corporations (Wang and Slack, 2000, Wang and Olivier, 2003). As a result, the port community is getting more intricate and focused on the global players so that the port governance is getting more important and needs to be elaborated more (Olivier and Slack, 2006, Notteboom, 2010)

The PISs have proliferated and contributed to understanding the economic impacts of the ports both at the national level and at the regional level (Benacchio and Musso, 2001). In the methodological sight, the port impact study (PIS) has been depending mainly on the input-output (IO) analysis (Artal-Tur et al., 2015) and made efforts to alleviate the limitation of the PISs of using the data from the IO tables (Park and Seo, 2016). On one hand, many researchers have applied the modified approaches of the IO analysis and/or the data from the evolved IO tables (Yochum and Agarwal, 1987, Danielis and Gregori, 2013). On the other hand, a huge body of research has introduced many alternative methodologies such as the microeconomic models (DeSalvo, 1994), the survey approach (Yochum and Agarwal, 1988), and the econometric analyses (Bottasso et al., 2013, Shan et al., 2014), whether they are based on economic theory or not. Especially, the econometric analysis has rapidly spread out in the PISs for the last decade (Park and Seo, 2016). Despite the efforts, the PISs still face the criticism such as the lack of a consensus on the methodology and the over-estimation (Dooms et al., 2015, Davis, 1983).[2] In addition, the PISs still have the methodological constraint not to well reflect the implications in the port studies: especially, with regard to the intensification of functional integration and port regionalisation. This is mainly due to the commonality that the PISs apply the methodology focused on estimating the magnitude of the economic impacts at a specific time period rather than unfolding the changes over time.

In order to fill the research gaps, this study tries to understand the longitudinal changes and the sectoral disparities in the economic impacts of the port-related activities by applying three different methodologies at the different level of a port, transportation and a regional economy. Firstly, at the level of a port, this study scrutinises the development path, the interaction with the city and the status in the national port system by applying various qualitative and quantitative methodologies. Secondly, at the level of a sector in a regional economy, the GVA per worker of transportation and the four sub-sectors in transportation are examined both at a national level and at a regional level by applying the shift-share analysis. Lastly, at the level of a regional economy, this study estimates the economic impacts of the ports on the regional economies by applying the econometric analysis in line with the previous studies (Park and Seo, 2016, Shan et al., 2014, Bottasso et al., 2013). Meanwhile, this study has the originality in the point of applying the sub-group analysis and regressing the coefficients by region.

[2] This is due to the inherent feature of the port-related activities, which are too complicated and intricate to categorize a single unit in Standard Industry Classification (SIC). By this reason, a number of PISs are likely to apply the IO analysis by using the data from IO tables but by applying the different classifications of the port-related industries (Davis, 1983).

1.2 Research objectives

This research aims to get a better understanding of the economic impacts of the port-related activities in relation to the surrounding changes; especially, the intensification of the functional integration and the spatial enlargement of the port-related activities in the supply chains. This study can clarify the key objectives as follow.

- To examine whether the structural changes have happened in practice or not in the sight of the port systems, focused on the changes in transportation and in its four-subsectors as a proxy for the port economic impact.
- To determine what research methodology can relate the structural changes to the economic impact of ports.
- To suggest what the port impact study (PIS) should take into account in applying the research methodology and understanding the results.

The main objective is to briefly examine if the structural changes: so-called, the functional integration and the spatial enlargement, happened in practice in the port system in South Korea. As mentioned previously, the discrete individual activities in the logistic networks are getting integrated and the port-related activities are getting embedded in the global supply chains over time (Robinson, 2002, Hesse and Rodrigue, 2004, Mangan et al., 2008). Especially, the structural changes have proceeded mainly in relation to transportation and the four sub-sectors of transportation under the goal of optimising the supply chains.

Secondly, the structural changes of the port-related activities also result in the reallocation of the economic benefits both between individual activities such as trucking, warehousing, and the other value-added activities (Notteboom and Rodrigue, 2005) and between the regions where each port is located (Hall and Jacobs, 2010). This study aims to determine which methodology can examine the sectoral and regional changes in the GVA per worker of transportation and the four sub-sectors in transportation, based on an understanding of the characteristics of individual ports.

Lastly, this study intends to clarify the considerations that the PIS should take into account in applying research methodology as considering the structural changes. The structural changes may happen differently by activity and by region. This suggests the significant implication that the regional economies may have statistically strong heterogeneity in the case of the longitudinal cross-sectional data: the so-called panel data. In addition, this may increase the risk of the biased estimation that the conventional approaches in the PISs have faced since the regional economies may violate the implicit assumption that regions have the same or a similar economic structure. This study approaches the goal by applying several different methodologies.

1.3 Research Scope

This study implements an empirical analysis applying various quantitative methods at the different levels with the data from regional accounts. The scope of this study can be introduced in three different aspects: methodology, geographical boundary, and time scope.

This study consists of three individual but related empirical analyses in order to meet the research objectives; especially, focusing on the relationship between the intensification of the functional integration and the spatial enlargement of the port-related activities and the economic impacts of the ports. Firstly, at the level of a port, this study scrutinises the development path, the interaction with the city and the status in the national port system by applying various qualitative and quantitative methodologies. This step is quite important to exactly understand the meanings of the analyses results at the port level and at the regional economy level with regard to the port systems which are influenced by the various geopolitical socioeconomic factors as a part of a national system (Lee and Lam, 2017). This approach will show which ports are a container freight-centred port and may be embedded much more in the logistics networks and the supply chains as considering the functional integration and the spatial enlargement of the port-related activities.

Secondly, at the level of a sector in a regional economy, the GVA per worker of transportation and the four sub-sectors in transportation is examined by applying the shift-share analysis. This step shows whether any structural change has taken place in transportation at the national level and at the regional level or not and how the economic impact of the changes has appeared in the statistics. The shift-share analysis has such a powerful strength with respect to the research objective of this study. The approach is quite reliable to analyse both the sectoral changes in a regional economy comparing the ones in the national economy and the regional difference in the specific industry (Artige and van Neuss, 2014). Focusing on the research objective, this approach will supply considerable information about both which activities and which regions may get more economic benefits over time. By the intuition of the author, the regions with the ports embedded in the supply chains may get more economic benefits under the changes but the regions with the ports weakly related to the supply chains may experience some outflow in the value-added. In addition, the disparity may result in the greater differences in the sectoral structure of transportation and regional economies. This suggest the significant implication with regard to the application of the econometric analysis.

Lastly, at the level of a regional economy, this study estimates the contributions of the ports to the regional economies by applying the econometric analysis in line with the previous studies (Park and Seo, 2016, Shan et al., 2014, Bottasso et al., 2013). Meanwhile, this study applies the sub-group analyses and the application by region. By comparing the results, this study aims to show that each port has brought different economic impacts according to the features of individual port: the volume of port traffic, the cargo composition and the extent of supplying the port services. This analysis will supply the statistical analysis between the port-related variable and the growth of regional economies so that support to understand the results of the shift-share analysis. As well, three different applications of the econometric analysis will suggest significant implications with regard to the research methodology in the PISs. Especially, this study will show what happened in that the regional economies with different structures are regressed based on the implicit assumption that individual regional economies have the same or a similar sectoral structure.

On another hand, in the sight of the geographical scope, this study applies the administrative boundary of the regional government. In the PISs, it is quite important to decide what geographical boundary is applied: local, regional, national and international dimensions. The geographical scope depends not only on the research goal that the researcher wants to meet but also on the spatial boundary that the economic impacts take place (Coppens et al., 2007). Conventionally, the PISs have focused on the impacts at the level of the national economy in order to attract financial investments on port projects: however, for the recent decades, the PISs are more likely to be implemented at the dimension of regional economies (Dooms et al., 2015). This study also conducts the empirical analysis at the regional dimension, as considering the trend in the PISs and the limitation with regard to the data acquisition.

On the other hand, in the sight of time scope, the PISs are generally divided into two groups: a static analysis and a dynamic approach. It is clear that a dynamic approach provides more significant information about the longitudinal trend than a static analysis does (Coto-Millán et al., 2010). This study applies a dynamic approach with the data for 25 years from 1990 to 2015, as focusing on the objective of understanding the structural changes in transportation over time rather than estimating the magnitude of the economic impacts at a specific time. In addition, this study will conduct the empirical analyses with the secondary data produced by the Korean government in order to mitigate the debates with regard to the data; for example, the arbitrary classification of the port-related activities and overestimation.

1.4 Research Procedure

This study, which consists of eight chapters, is made up of five steps, as shown in Figure 1-1, to achieve the research objectives. Firstly, this study provides a robust basis and the clear direction of this research in Chapter 1, which consists of background, research objectives and research scope.

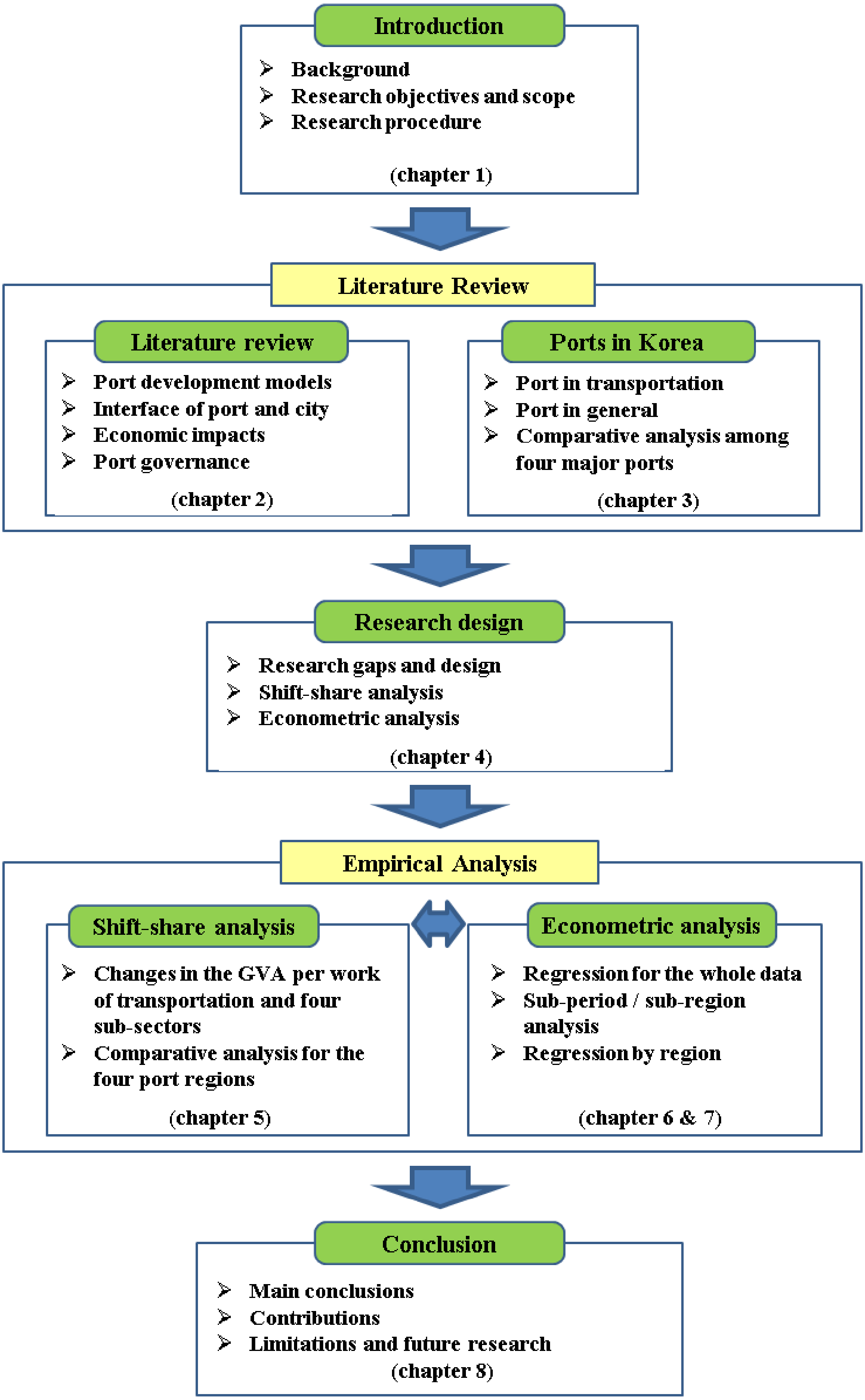
As the second step, the literature review is following. On one hand, the literature review at the level of a port rather than at the level of a terminal is conducted in Chapter 2. The chapter, covering the main goal of this study, overviews the models of port development, the port governance, the interface between a port and a city, and the economic impacts of the ports. This chapter fundamentally supplies the background for understanding what the hot issues have been in the port studies in recent decades and why this research has several research questions and research gaps. As well, this chapter supports to understand what and how this research examines at the port level in Chapter 3. On the other hand, this study introduces the general information of the port systems in South Korea in Chapter 3. This chapter covers the status of the ports in transportation, the port classification, the general information of the port facilities and port governance. As well, this chapter supplies the characteristics of the four major ports by applying comparative analysis based on the contextual understanding for individual port.

Based on the overview of ports in principle and in practice, this study introduces the research design and methodology in Chapter 4. In the sight of research design, this study introduces where this study begins from and goes to, what variable is analysed and how the analyses are conducted. In addition, the main methodologies: the shift-share analysis and the econometric analysis, are overviewed. This chapter supplies the background on how to conduct the empirical analysis and how to interpret the results for Chapter 5,6 and 7.

As the empirical study, this study introduces the results of three different analyses in four chapters. Chapter 3 introduces the results of comparative understanding for the four major ports. Secondly, Chapter 5 produces the results of the shift-share analysis focused on the annual changes in the GVA per worker of transportation and the four sub-sectors in transportation at the regional economies. Thirdly, Chapter 6 delivers the results of the econometric analysis for the panel data, focused on the statistical relationship between the port variables and the growth of a regional economy, by applying the sub-group analysis. Lastly, Chapter 7 discusses the results of the application of the econometric analysis by region. The relationship between the four chapters shown in Figure 4-1 will be introduced in detail in Chapter 4.

As the last step, Chapter 8 clarifies the main conclusions of this empirical analyses of applying the three methodologies. Furthermore, the contribution, including the implications for the port studies and the port policies, and the limitation of this research are discussed.

Figure 1-1 Flow chart of this research



Chapter 2 Ports in Literature

2.1 Introduction

Port study is strengthening the position as the multi- and inter-disciplinary research area from the research area with three independent pillars: geography (transport or port geography), economics (maritime or port economics) and management (or logistics). This feature has been formed decade by decade while reflecting the social and economic changes, based on the theoretical basis by port geography in the 1950s and 1960s (Ng et al., 2014, Notteboom et al., 2013b, Woo et al., 2011, Heaver, 2006, Olivier and Slack, 2006).

As the first pillar, port geography grew both quantitatively and qualitatively in the 1960s while trying to establish and foster the general theory of port development focusing on the spatial and functional characteristics. However, this stream did not prolong until the 1970s and port geography has recovered the publications through reflecting the changes of maritime transport technology, global production, global logistics, and supply chains on the port study from 1990s (Ng et al., 2014). On another hand, maritime (or port) economics began to be published more and more in the 1960s since the analytic economic methodology was applied, for the first time, to port study in the late 1950s. In addition, going through the 1970s, economists' interest skyrocketed and resulted in the large number of books and papers published, focusing on cost analysis and pricing, port performance, and port competitiveness (Heaver, 2006). On the other hand, management (logistics, terminal related issues in the level of the operator) made a rapid progress while it has scrutinized the behaviour and strategy of participants in the transport network such as mega maritime carrier, global terminal operator, and inland terminal operators (Olivier and Slack, 2006).

Due to the above feature, the port studies are likely to have the broad boundary with small core area (Pallis et al., 2010). Accordingly, in order to understand better how a port influences a regional economy or society, the port-related research would better consider both spatial and economic changes together (Ducruet, 2006). For this reason, it is crucial to look over a port and its city with the lens both of the spatial aspect and of the economic aspect.

As such, this research reviews the literature in the port studies as below. The models for the port development follows, focused on the key factor of enhancing the growth of ports, in the next section. Secondly, the research with regard to port governance is breifly reviewed in the third section. Thirdly, this study discusses the interaction of ports with their cities, focused on the concept of the interface, in the following section. Lastly, this study introduces the literature related to the economic contribution of the ports in the fourth section: mainly, focused on the methodological issues.

2.2 Port Development

There can be various criteria to categorise each approach to several groups by the purpose, the scope and the methodology of each study. Furthermore, it is getting more complicated to set the framework of port studies since the 1990s when the surroundings of the port industry and the port systems have changed with unprecedented speed (Bichou and Gray, 2005). For instance, Olivier and Slack (2006) who put the stress on the behaviour approach to port study classify port development models into four: the spatial approach, behavioural approach, governance approach, and fundamental factors. Meanwhile, Lee et al. (2008) who focus on the role of the port classify port development models into three groups: port as concentration point between hinterland and foreland; port as nodes in intermodal systems; and ports as an agent of regionalization and globalization process.

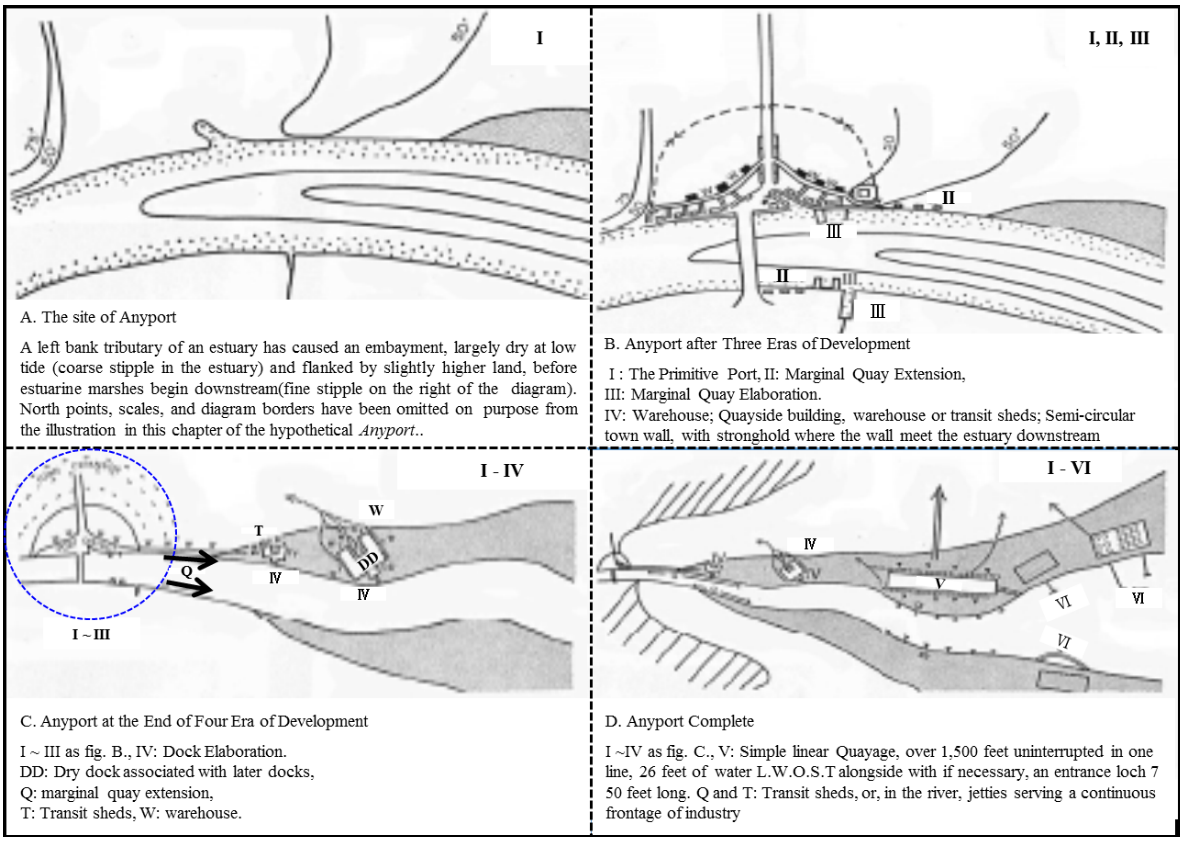
This study classifies the models into five groups by the key factor to drive the development: spatial approach; transport network approach; governance approach; port regionalisation; and others.

2.2.1 The spatial approach

From the end of the 1950s, a number of researcher began to study about commercial ports which had flourished since the 19th century. They focused on the port and transport networks, port and its hinterland, and the interaction of a port and its city. In increasing interests on the port study, Morgan (1952) published a book which focuses on the spatial and formative features of ports and it stimulated scholars to develop the common models of port development (Lee, 2006). Specifically, it contributed Bird (1963) to make a comprehensive survey on the major ports in the UK and suggested 'the Anyport model' which gives a conceptual frame to understand the effects of freight flow from the hinterland to foreland and to inspect relations between port types and functions before a container evolution (Robinson, 2002).

Bird's 'Anyport model' is to attract the characteristics in common from commercial ports in the UK and categorise the path of port development to six eras: the primitive port, marginal quay extension, marginal quay elaboration, dock elaboration, simple linear quayage, specialised quayage. As seen in Figure 2-1, the anyport, located in the adjacent area from the city centre, has enlarged quays and its capability to handle the increasing cargos by ships. After then, it elaborated the layout of facilities through the second era. Meanwhile, the anyport, which could not meet the demands, has developed new facilities; specifically, dry dock, at some place far from the central business district alongside the river and elaborate the layouts focusing on the dry docks at the third and fourth era. Furthermore, the anyport has moved forward the area, which gets bigger to arrange supporting facility next to the dock, down the river and developed the linear wharves to accommodate the large-scale ships through the fifth era and the sixth era.

Figure 2-1 James Bird's ‘Anyport Model’



Source: revised by the author based on Daamen (2007, p. 3).

Bird considers, as the key factors of port development, the explosive increase of the international cargos by ships and the technical changes in both the shipping industry (e.g. enlargement of the ship) and the port industry (e.g. advance of cargo handling facility). With regard to this, Monios and Wilmsmeier (2012a) evaluate that the general development strategies are not only moving to larger berths with deeper water but also moving to specialised facilities for the cargo types (e.g. oil, container). Furthermore, in terms of the management of the old port facilities, it suggests the critical implication that some of the existing facilities can be adapted for the new layouts and the new demand (Daamen, 2007). Meanwhile, according to Olivier and Slack (2006), Bird’s main interest is on “how the morphology of the port came to interact with that of the city (p. 1412)”. It is quite reasonable in the point that the anyport has extended its spatial boundary from the area near the CBD to the outskirts alongside the river and to the downstream.

Due to the characteristics above, the Anyport model is evaluated to supply the clue for the various issues in the port studies; the application of the model in the Asian ports (Robinson, 1985), the port-city relationship and the separation from the city (Hoyle, 1989) and the port life-cycle (Charlier, 1992, Charlier, 2013). As mentioned by Olivier and Slack (2006), the widespread applications are mainly because the chronologically spatial approach explain well the relationship between the port and the port-city in the sight of both how the port facilities migrate to the more periphery areas and how the derelict area in the old port is reused or renewed. On the other hand, according to Notteboom and Rodrigue (2005), the Anyport model can be transformed the three-phase model: setting, expansion, specialisation, and can be extended to the regionalisation model to explain the recent phenomena in the sights of the port function and the port development.

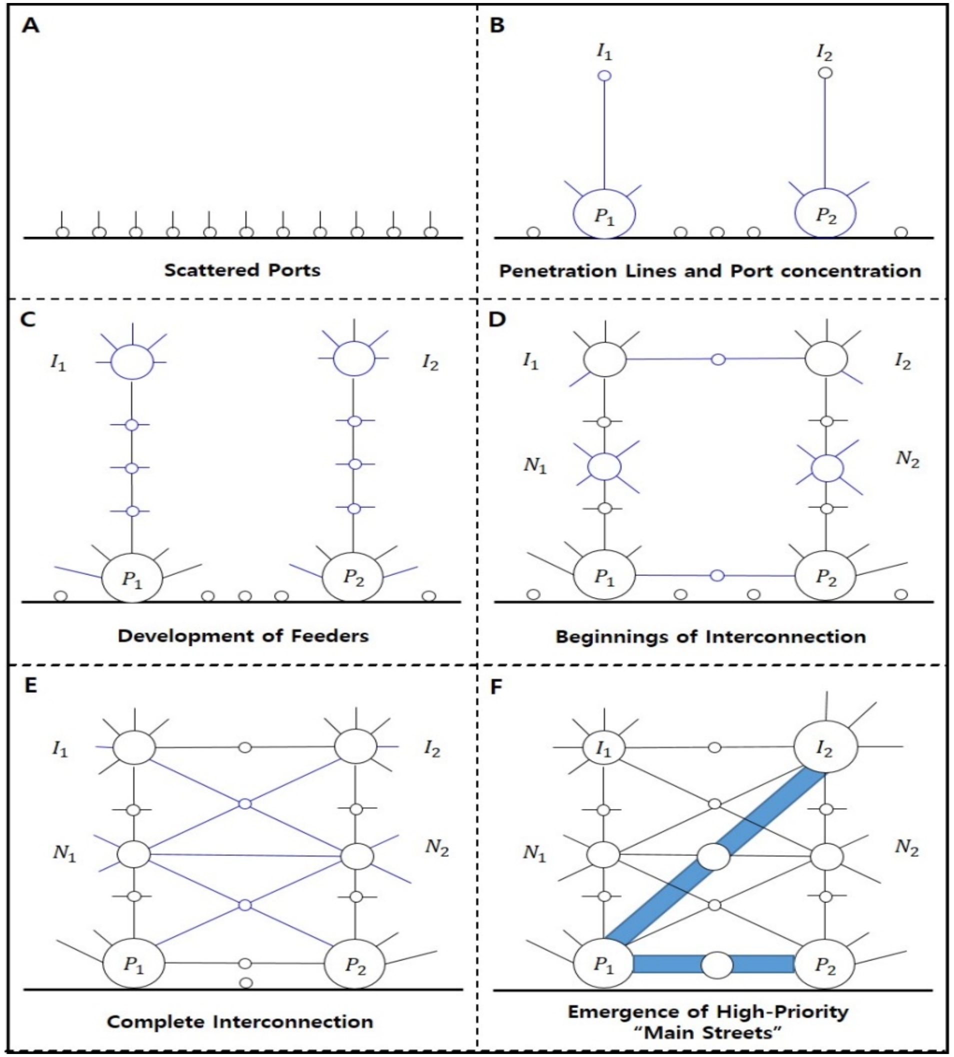
Despite its various contributions, the model has faced, for the last several decades, the criticism that it focuses on the morphologic changes between a port and its city and the results caused by “a direct relationship between form and function” (Olivier and Slack, 2006, p. 1412). In addition, the model has the limitation not to explain the importance of the port topology (hinterland-port-foreland) neither to consider the role of the hinterland or the transport networks: especially, road and rail. For these reasons, even though this model recognised the containerisation as the change in the cargo type, it cannot explain the various phenomena related to the containerisation such as the concentration and the de-concentration, the competition and the co-operation among ports or terminals, the impact of the containerisation on the city, etc. (Lee et al., 2008).

2.2.2 Transport network approach

Compared with Bird’s morphological approach, there are several approaches to explain the port development by applying the topological methodology in relation to the transport networks or the port topology. According to Olivier and Slack (2006), these topological approaches had been widespread in the port studies at the large scale since the early 1960s. The first model by Taaffe et al. (1963) has been succeeded by many following studies such as Rimmer (1967b), Hoyle (1968), and Hayuth (1981), etc. This study briefly reviews the three models except for Hoyle’s work in the order of the published year.

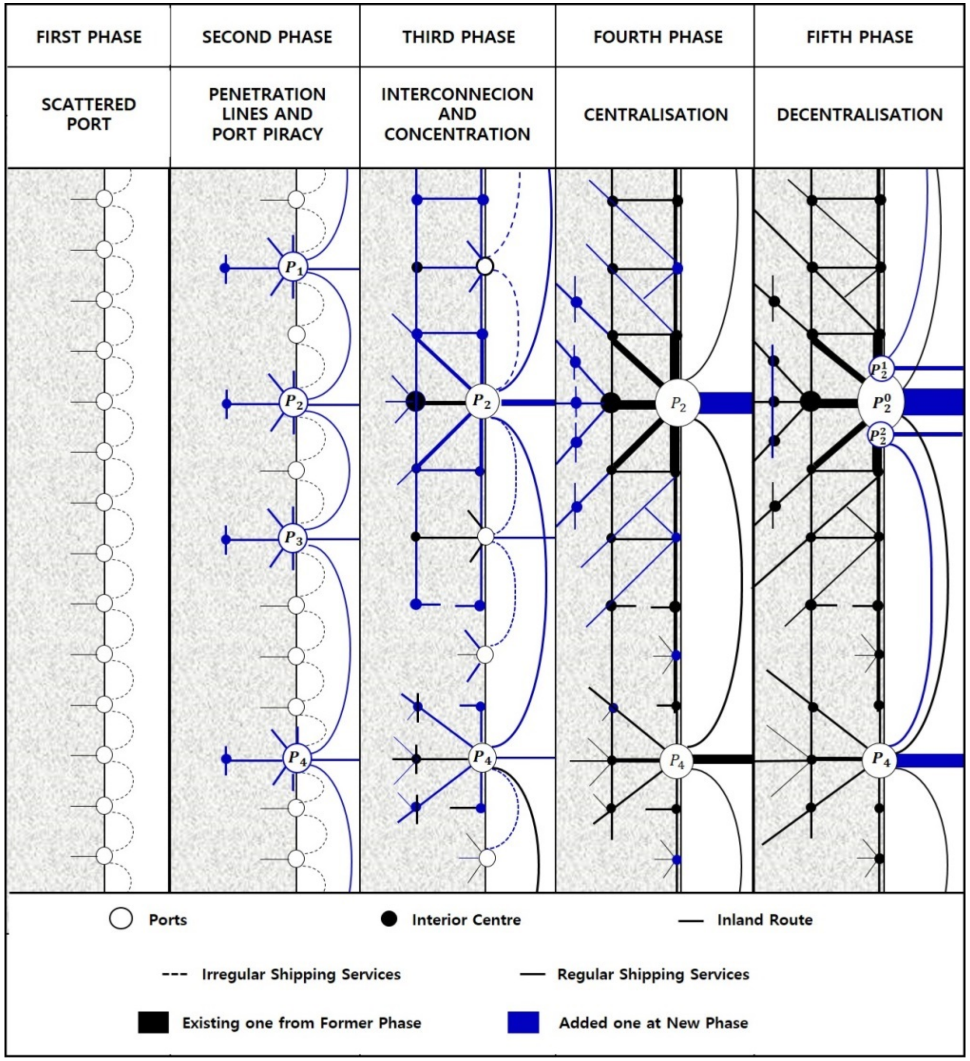
In the same year with the Anyport model, Taaffe et al. (1963) suggested the model (henceforth TMG model) focusing on the land transport networks as the key factor of port development. The model was introduced, as the result of the unpublished report for the U.S army in 1960, to explain the port development process as examples of ports and inland cities in Ghana and Nigeria. This model consists of six steps: scattered ports, penetration lines and port concentration, development of feeders, beginnings of interconnection, complete interconnection and emergence of high-priority ‘main streets’. As shown in Figure 2-2, scattered ports, in the beginning stage, come out respectively without any connectivity with the inland city. However, as some of them penetrate to the inland city and have better accessibility, they start to make the transport networks with the inland city and even with other ports. Finally, the ports, which have the complicated interconnection with the inland cities, are positioning as the central port in the stratified port systems. This model has strength in that it explains well the relationship between the port and its hinterland, the importance of transport networks in the port development (Olivier and Slack, 2006) and the hub & spokes system in the

Figure 2-2 Sequence of transport development suggested by Taaffe et al.



Source: drawn by the author based on Taaffe et al.(1963, p. 504).

Figure 2-3 Sequence of Port Development suggested by Rimmer



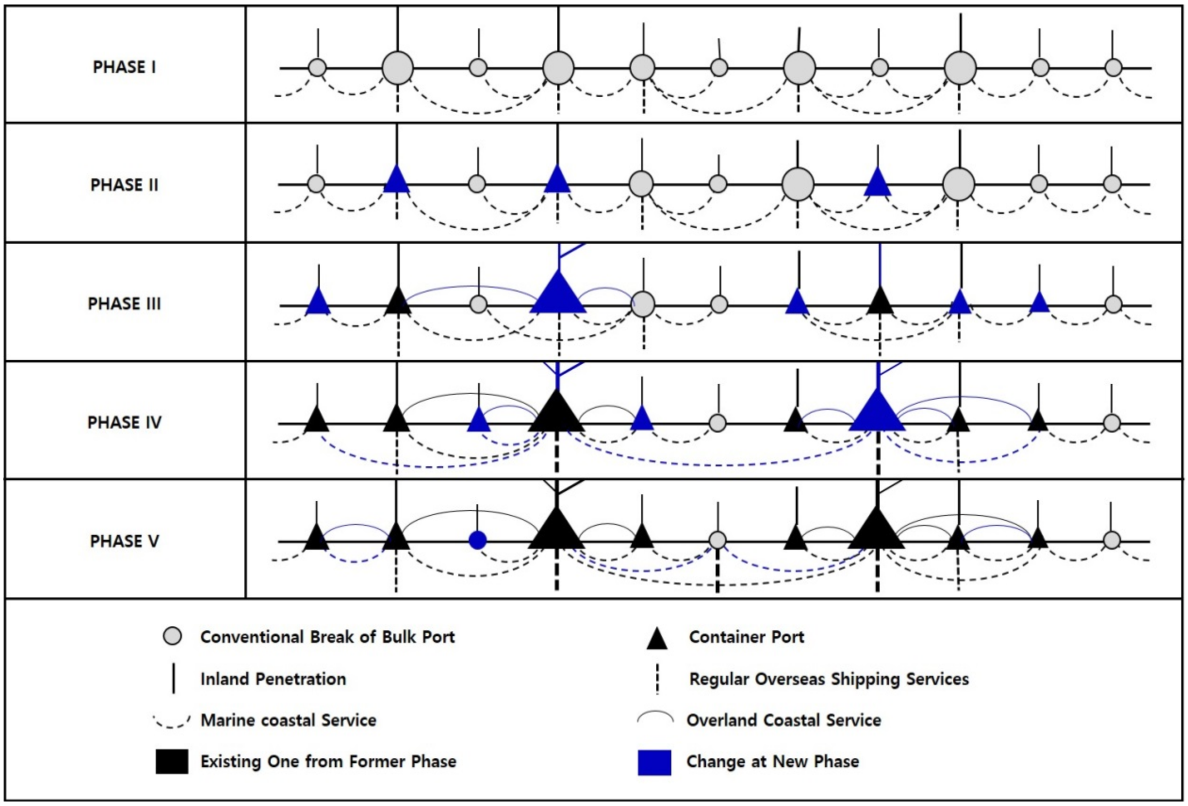
Source: drawn by the author based on Rimmer (1967b, p. 90).

container shipping liners. However, there is the limitation not to consider the relationship between port and port-city and overlook the influence of the various changes in the surroundings with regard to the port development through overemphasising the importance of the transport networks.

As the further developed type of the TMG model, Rimmer (1967b) suggested the process of port development focusing on the distribution function of the land transport networks as examples of ports in Australia and New Zealand. This model consists of five phases: scattered ports, penetration lines and port piracy, interconnection and concentration, centralization and decentralisation. As shown in Figure 2-3, some of the small ports, which are scattered in the first phase, have developed the transport networks with the hinterland and absorbed in the adjacent small ports at the same time in the second phase. Furthermore, the developed ports in the second phase have grown consistently and built the mutual contact with the swarmed cargo continuously thanks to the superior accessibility and service networks. In the fourth phase, the high ranked ports began to differentiate from the low ranked ports so that they have constructed the networks and the corridor with the hinterland. In the last phase, while the central ports keep the networks with the hinterland, it has decentralised its function to small ports in the adjacent area due to the various problems derived from over-concentration: for examples, the shortage of its capability and the heavy congestion, etc. This model focuses just on the linear connectivity between the port and the hinterland as a node in the transport networks in the sight of the intermodal transport. Due to these characteristics, this model is evaluated to supply a clue for the competition and the concentration among ports (Olivier and Slack, 2006). Although this model is systematised much more than the TMG model, it has the shared limitation not to consider the spatial aspect like the port-city interface and the changes in the port development trajectory.

On the same line with the former models, Hayuth (1981) suggested the model in Figure 2-4 which systematises the new development pattern of the container ports in the relation of the hinterlands, the forelands, and the ocean trade routes. The model consists of five phases with the containerization and the intermodal transportation system focused. The first phase of the preconditions for a change is that the conventional ports are scattered and have the networks with the hinterlands and other ports respectively. The second phase: namely, the initial container port development, shows that the container terminals appear in order to accommodate the container dedicated ships. In the second phase, the port systems are not significantly different from the conventional port systems. In the third phase: so-called, the diffusion, consolidated, and port concentration, the containerisation continues to expand into the other ports. However, some ports adopted the container dedicated facilities to attract the containerised cargos and have the initial advantage to preoccupy the new refined networks based on the centre & sub-centre relations. In the fourth phase: the load centre, the containerised cargos concentrate on the main ocean route and the intermodal transportation system is constructed to the port with the main ocean route. This is mainly for optimising the operation of the container ships and minimising the costs of the shipping liners. This continuously accelerates the concentration

Figure 2-4 Development of the container port system suggested by Hayuth



Source: drawn by the author based on Hayuth (1981).

of the sea-borne cargos and the feeder services are introduced in order to connect the dominant port with the peripheral ports. However, in the last phase: the challenge of the periphery, the dominant port meets the various problems such as the traffic congestion, the shortage of the space, and the small port attracts some container carriers by supplying the various incentives.

These transport network approaches, including Hayuth's model introducing the containerisation, face some criticisms to the point that these approaches have studied ports in Europe and North America. As such, the application of the transport network approaches in Asian ports may suggest the quite different results from the original models in the sight of the port systems and the development process. The case studies of Singapore and Hong Kong show that the relationship between the port and the city is quite different from the one of the ports in the developed countries (Wang, 1998, Slack and Wang, 2003, Lee and Song, 2005). In addition, these models cannot explain the new phenomenon; for example, the change in the role of the port as an integrated component in the logistics network or the global supply chains (Robinson, 2002), the enlargement of the port function to the hinterland, and the emergence of the transhipment-dedicated port (Notteboom and Rodrigue, 2005, Rodrigue and Notteboom, 2010). Lastly, these approaches cannot consider the features of the city and the characteristics of the institutions as a factor of supporting and/or constraining the port-related activities (Olivier and Slack, 2006).

2.2.3 Governance approach

The transport network approaches had been widespread in port geography and played a role as the most powerful epistemological discourse by the 1980s (Olivier and Slack, 2006). However, the approaches have the limitation that it does not reflect the various changes in the surroundings since the 1980s, even though it contributes to understanding the features of the intermodal transportation. For this reason, Robinson (2002) insists that the new paradigm which can reflect the changing characteristics of the global logistics networks and the global supply chains should be considered in the port studies. In addition, he stresses that the port-related activities encounter the unprecedented changes from the surroundings: for instance, the globalization, the corporatization, the privatization, the exceptional competition, and the logistics restructuring.

On one hand, Olivier and Slack (2006) insist that the port study should be implemented based on the assumption that the ports are a component of the global intermodal networks and the global supply chains. In addition, the ports are likely to be controlled mainly by the participants in the port community such as the shippers, the ocean liners and the global terminal operator (henceforth GTO), etc. This epistemology is in the line of the recognition of Willingdale (1984) that the ports did not have the whole right to decide its own destiny but were under both the pressure and the influence from their various users. Furthermore, a number of researchers have followed this line and developed to understand the behavioural characteristics and strategies of stakeholders; especially, the mega ocean carriers and the GTOs (Slack, 1985, Hoare, 1986).

On the other hand, the emergence of the mega port and the port logistic complex in East Asia attracted the attention of researchers and delivered some implications of several empirical research on port studies (Olivier and Slack, 2006). The notable outcome are as follows: the effect of the privatization and the relationship between the container terminal and the peripheral facility (Wang and Slack, 2000), the policy conditions in the regional system (Slack and Wang, 2003), and the influence of institutional characteristics on the port system and the spatially discontinuous development of port system (Wang and Olivier, 2003).

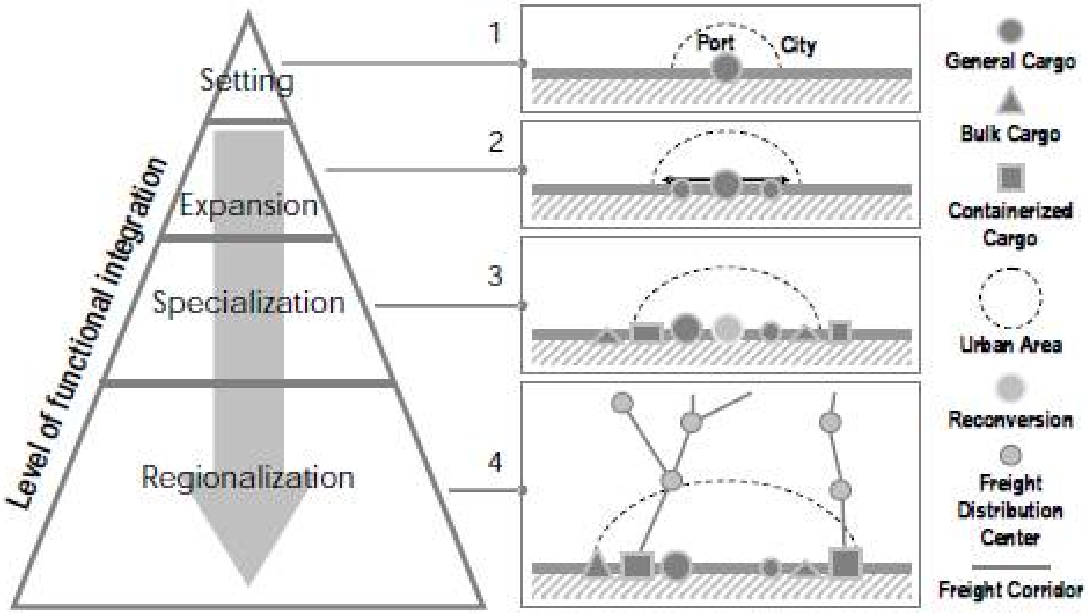
These approaches make a positive contribution to recognising that the ports in East Asia are worth studying by applying the different sight from the ports in the developed countries. In addition, they conceptualize the new factors such as the influential participants, the privatization of the container terminal, the policies and the institutional engagement, etc. (Olivier and Slack, 2006). However, these approaches are not systematized to the generalised model. In addition, it is not feasible to generalise the cases of the mega-ports in East Asia to the ports in the other parts of the world. Specifically, each factor like the strategic decision of some participants cannot explain individually the changes in the port system and the surroundings of the port industry.

2.2.4 Port regionalization

Notteboom and Rodrigue (2005, p. 297) diagnose the change of the surroundings and prescribe the direction for port study in their paper: "logistics integration and network orientation in the port and maritime industry have redefined the functional role of ports in value chains and have generated new patterns of freight distribution and new approaches to port hierarchy". They point out that the existing models cannot explain wholly the changes in the surroundings in the light of the spatial evolution and the transport network variation. Especially, the existing models cannot explain why the global logistics system is concentrated and agglomerated in the port district or around the boundary of the port cities. In addition, it is beyond the existing models to explain why and how several ports appear without their own hinterland and how they play a role of the transhipment port with the examples of Freeport (Bahamas), Tanjung Pelepas (Malaysia), Salalah (Oman), Algeciras, etc.

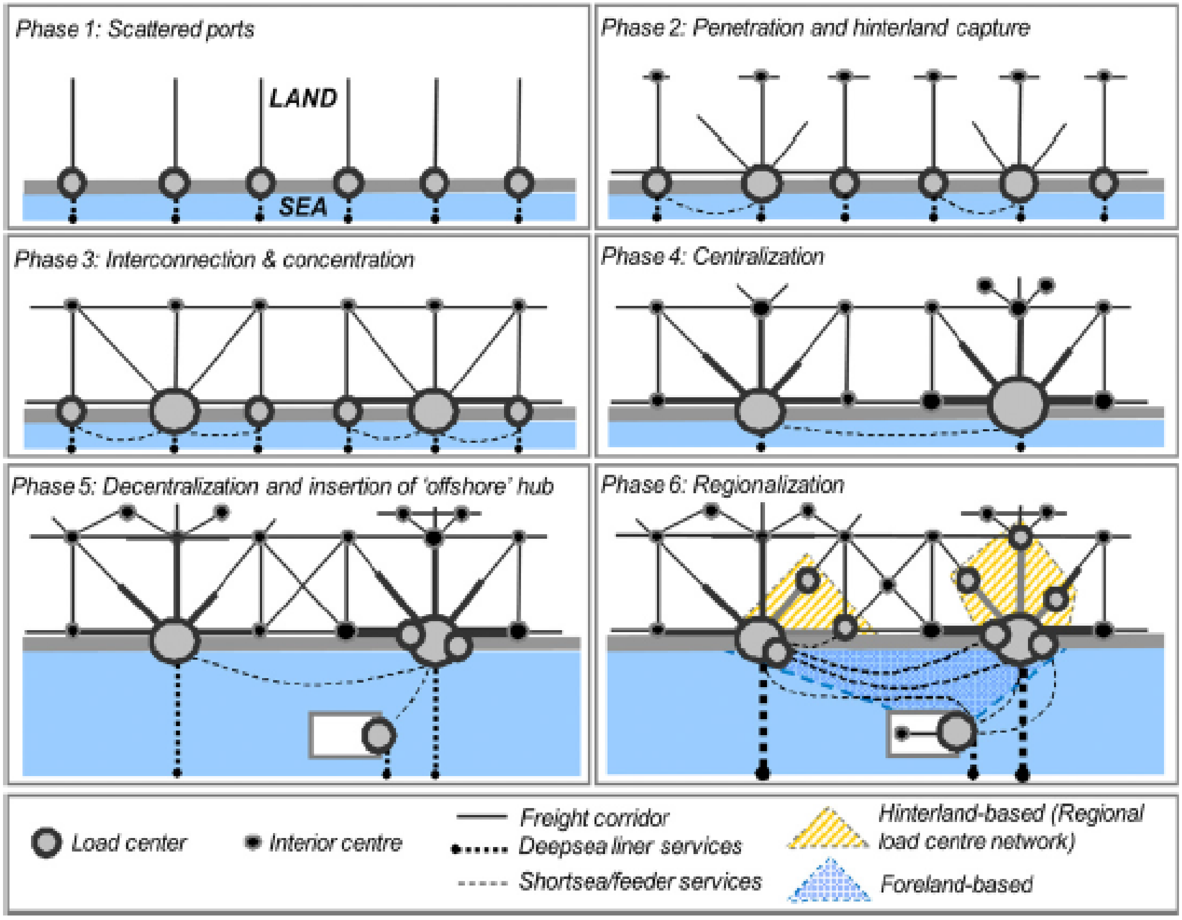
In order to overcome two limitations in the existing models, Notteboom and Rodrigue (2005) suggest the model by revising and extending the Anyport model and the TMG model: so-called, the port regionalization refines the existing steps and adds another step. On one hand, they identify the six phases of the Anyport model to three major steps: setting, expansion and specialisation as shown in Figure 2-5. Then, the regionalisation is extended as the fourth step. They prescribe the regionalisation as the development phase that the port connects functionally with the hinterland where the inland freight distribution centre is located due to the various strategies (e.g. vertical integration) of the participants in the global supply chains.

Figure 2-5 Regionalization as the last step of the port development



Source: Notteboom and Rodrigue (2005, p. 298).

Figure 2-6 Port development model by Rodrigue and Notteboom



Source: Rodrigue and Notteboom (2010, p. 21).

As a result, in the phase of the regionalization, the whole issues of the port development are likely to be decided in the relation of a number of related organisations at a higher geographical scale, i.e. beyond the port district and its municipal administrative. On the other hand, they show the spatial development of the port system as shown in Figure 2-6, based on the TMG model; indeed, it is based on the perception of the TMG model and reflected other transport network models (Hayuth, 1981, Barke, 1986). With regard to the port system, they recognise it as maritime and hinterlands network and analyse concentration/deconcentration based on container terminal level, stressed in several studies (Notteboom and Winkelmans, 2001, Robinson, 2002, Olivier and Slack, 2006).

Under this epistemology, the ports begin to be decentralized by connecting the adjacent small ports and/or inserting the 'offshore hub' when the centralised port enters into the scale of diseconomies due to the traffic congestion and/or the space shortage in the fourth phase. Then, in the phase of the regionalisation, the port systems have the interconnection of hinterlands-port-maritime networks. Consequently, the port becomes a key component to connecting between the modes in the transport networks and its functional boundary enlarges to the hinterlands beyond its geographical district.

This model focuses on the impact of the spatial enlargement of the port-related activities in the logistics networks to understand the concentration and the de-concentration among ports on the global port system. Although there is the debate, raised by Rimmer (2007) and Rimmer and Comtois (2008), what regionalisation is different from the existing concentration/deconcentration recognition, it contributes to the port study in the various aspects. As a result, this model is very helpful to understand the process that the structural changes in the logistics networks or the supply chains have immersed to the port systems: especially, the impact that the strategic decisions of the participants in the transport networks have affected to the functional boundary of the port (Monios and Wilmsmeier, 2012a). As a result, this model supplies lots of implications in the sight of port impact study (PIS); especially, with respect to the redistribution of the economic benefits between the activities in the supply chains and between the port regions and the inland regions.

2.2.5 Others

UNCTAD (1992) suggested a three-generation port model that the degree of port development can be classified by six criteria to three groups: the first generation before the 1960s, the second generation between the 1960s and the 1980s, and the third generation after the 1980s. With regard to this, Beresford et al. (2004) proposed the WORKPORT model in which contemporary characteristics of European ports were specified by eight criteria and concluded that port does not follow the developmental cycle like generation but develops to meet the needs gradually. On the other hand, Lee et al. (2008) suggest that individual port or port system should be understood in the context of the relationship with major market areas; the role of a port is decided in the relation with concentration place in the sight of port typology.

2.2.6 Summary

The characteristics of the changes which occur in the sight of the role or the status of the port are expressed well in the title of the paper, by Pettit and Beresford (2009), "port development: from gateways to logistics hubs".[3] Conventionally, the theoretical study of the port was focused on the spatial and locational point (Lee, 2006). In fact, this recognition changes slowly through experiencing the various changes from the surroundings for the last several decades. As discussed above, the function of the ports has changed while customising the needs for the port-related services over time. Hayuth (1981) reflected the containerization as a standardisation on the model of port development.

[3] 'gateway' became a common spatial term to represent the port-city since R.D. McKenzie discussed the concept of it for the first time in 1993 (Rossi and Taylor, 2006), while comparing with the city in central place theory (Burghardt, 1971). The concept of the gateway is focused on locational sight as a combined entry/exit for a given area or region. In this regard, Bird (1983) specified the characteristic of the gateway as the centre of exchange; especially, free of trade with other region or country and open to outside influences. To be specific, he recognised that the gateway is based on the long distance transport modes: air and sea transport.

In addition, Hayuth (1982a) recognised the importance of the port in the intermodal transport system and insisted the role of the port as an intermediary between land transport and sea transport, as considering the discontinuity of foreland (sea transport-other port-hinterland). By extension, UNCTAD (1992) proposed the role of the port in the network of organisations in logistics.

Turning the new millennium, a considerable body of port literature recognises the role of the port as integral components of distribution systems in the sight of global supply chain management through the vertical integration[4] with strategic partnerships and co-operation arrangements (Bichou and Gray, 2004). On another hand, some researchers focus on the spatial enlargement and integration between port district and hinterland out of the port city through connecting the services (Notteboom and Rodrigue, 2005). Monios and Wilmsmeier (2012a) suggest that the point answered is why port regionalisation appeared in the port systems and how port authorities adjust their policies to this change rather than if port regionalisation takes place in. On the other hand, some researchers have lots of interests in the functional importance as the centre of the supply chain through adding some value-added services on its conventional role (Bichou and Gray, 2005, Mangan et al., 2008, Pettit and Beresford, 2009).

These suggestions with regard to the function of ports are still supplying significant implications in the sight of port impact study (PIS) as discussed in the later section. The changes such as the intensification of the functional integration and the spatial enlargement of the port-related activities may bring the redistribution of the economic outputs of ports between the activities and the regions. In other words, the activities integrated with the port-related activities and the regions with the ports embedded in the supply chains may get more economic benefits under the changes but the regions with the ports weakly related to the supply chains may experience some outflow in the value-added. On the other hand, these changes may result in the greater differences in the sectoral structure of transportation and regional economies. If this happened, the conventional approaches in the PISs may not be free from the risk of overestimation and underestimation of the economic impact. This study will discuss the further details in the later section.

[4] The vertical integration indicates that the various activities in the logistics networks or in the supply chains are integrated by a corporation in order to rationalize the logistics flow and cut down the costs. Meanwhile, the horizontal integration means that individual activities in the supply chains increase the capability to supply the service by merging and/or co-operating other corporation to supply the same service.

2.3 Port Governance

2.3.1 The concept of port governance

Definitions of governance are various as many as the authors are. According to van Kersbergen and van Waarden (2004), cited in Jordan et al. (2005, p. 478), 'there is not even a consensus on which set of phenomena can properly be grouped under the title of governance.' In practice, the governance is understood and used with various definitions (Tambulasi, 2011): for example, 'self-organising, inter-organisational networks' (Rhodes, 1996), 'structures of political and economic rules' (Leftwich, 1994), and 'fundamental rules to regulate the relationships between rulers and the ruled' (Olowu, 2003). Kaufmann et al. (2000, p. 10) define the governance as 'the traditions and institutions by which authority in a country is exercised for the common good' with three angles[5] applied. Robinson (2007, p. 522) defines governance, as 'the manner[6] in which the state acquires and exercises the authority to manage public goods and services'. Even though there are a number of definitions, it is clear that the definition of governance, which is a different term from the government (Tambulasi, 2011, p. 334)[7], is focused on institutions and administrative structures of relationships between government and other actors whether intangible and spiritual characteristics are included or not.

Governance studies in port research began to develop in the early 1990s and have been getting abundant with various research objectives (Tambulasi, 2011)[8] in the line that ports are a kind of business cluster which port- or logistics- related industries come together in specific areas (Notteboom et al., 2013a). With regard to research objectives, as mentioned by Brooks and Pallis (2008), port governance studies are mainly focusing on the analysis of governance models and their relationship with port performance. Due to these research trend, there has been some research (De Langen, 2006, Monios, 2015) in which port governance is defined academically. De Langen (2006)[9] argues that the concept of port governance should be divided into two different terms of governance; port governance and the port authority[10] (henceforth PA) governance. The former is mainly related

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[5] The definition consists of the process by which those in authority are selected, monitored, and replaced (the political dimension); the government's capacity to effectively manage its resources and implement sound policies (the economic dimension); and the respect of citizens and the state for the country's institutions (the institutional respect dimension).

[6] Institutions are defined as 'sets of rules that shape the roles, behaviours, and expectations of social, political, and economic actors'. These institutions may be formally codified systems or informally embodied attribute.

[7] Government is generally regarded as formal and legal structures of representation and decision making operating either local (local government) or national (central government) levels.

[8] Qualitative case studies which evaluate the changes of economic performance after governance reform are predominant.

[9] A port is regarded as a cluster which consists of independent organizations with few formal control relations to govern their interactions.

[10] A port authority is generally understood as 'the entity, which whether or not in conjunction with other activities, has as its objective under national law or regulation, the administration and management of the port infrastructures, and the co-ordination and control of the activities of the different operators present in the port' (Verhoeven, 2010, 9. 251)

to cluster governance and the latter is linked with corporate governance which is focused on the structure of shareholders and governors, and corporate social responsibility, etc. On the other hand, Monios (2015, p. 768) argues that the governance is ‘a broader process of distributing authority and allocating resources, of managing relationships, behaviour or processes to achieve the desired outcome’. His broad understanding is in line with the view that traditional government institutions are only one component of the governance process as many actors are sharing power devolved from governments and have increased influence on the decision-making process (Jordan et al., 2005).

2.3.2 Approaches to port governance

Governance studies can be said to understand and classify who does what, where and how, based on the insight aimed by Fleming (1987). In order to do so, a number of port research focus on clarifying the relational characteristics among various entities including government and corporation in the different angles set by different objectives (Brooks and Cullinane, 2006a, Baltazar and Brooks, 2006, Alfred, 2002, Wang et al., 2004). These studies can be grouped into three streams by the key factors (Wang et al., 2004): the role distribution between public and private (Baltazar and Brooks, 2001, Brooks, 2004), the functional and spatial scope of the port-related activities in the logistics chains (Notte**b**oom and Winkelmans, 2001, Notteboom and Rodrigue, 2005), and the social and cultural features (Wang and Slack, 2002)[11].

2.3.2.1 Authoritative approaches

Focusing on the role distribution between public and private, Baird (1995) suggested four models as shown in Table 2-1 in line with the insight of Bascombe (1994) that there is more than one form of port privatization. Furthermore, as cited in Brooks (2004, p. 171), Baird (2000) suggests the governance classification model which is four categories in the port ownership and three categories in the port functions as shown in Table 2-2. This classification is revised the one in 1995 a little; changed the ‘landowner’ in 1995 to the ‘landlord’ in 2000, but has evolved meaning in the sight of the port governance.[12] From a slightly different angle, World Bank (2001) suggested the Port Reform Toolkit (WBPRTK), which outlined the four port administration models as shown in Table 2-3 and triggered the debates with regard to the port governance (Brooks, 2004). The WBPRTK model has contributed to proposing the directions of devolution in port administration with regard to who does what; especially, in the developing countries. Even though these models contribute to attracting lots of interests in the port governance issues, they have faced the debates that they are too simple to apply ports in the outside of western countries.

[11] They highlighted the institutional specificity: focusing on the regional legal frameworks.
[12] ‘Landowner’ is focused on the status ‘who own what’ but ‘landlord’ is focused much more on the role distribution ‘who do what’.

Table 2-1 Four models of the port administration

Models	Port functions		
	Landowner	Regulator	Utility
1 Pure public sector	Public sector	Public sector	Public sector
2 PUBLIC/private	Public sector	Public sector	Private sector
3 PRIVATE/public	Private sector	Public sector	Private sector
4 Pure private sector	Private sector	Private sector	Private sector

Source: drawn by the author based on Baird (1995, p. 136).

Table 2-2 Allocation of the responsibilities suggested by Baird

	Port functions		
Port Models	Regulator	Landlord	Utility
PUBLIC	Public	Public	Public
PUBLIC/private	Public	Public	Private
PRIVATE/public	Public	Private	Private
PRIVATE	Private	Private	Private

Source: drawn by the author based on Brooks (2004, p. 172).

Table 2-3 Allocation of the responsibilities in the WBPRTK model

Responsibility	Infrastructure	Superstructure	Port labour	Other functions
Service Port	Public	Public	Public	Majority public
Tool Port	Public	Public	Private	Mixed
Landlord Port	Public	Private	Private	Mixed
Private Port	Private	Private	Private	Majority private

Source: Revised by the author based on Brooks (2004, p. 171).

Table 2-4 Baltazar and Brooks' port devolution matrix

Governance	Regulator functions	Port functions	
		Landlord	Operator
Public **Mixed Public/private** **Private**	• Licensing, permitting • Vessel traffic safety • Customs and immigration • Port monitoring • Emergency services • Protection of public interest on behalf of the community • Determining port policy and environmental policies applicable	• Waterside maintenance (e.g. dredging) • Marketing of location, development strategies, planning • Maintenance of port access • Port security • Land acquisition, disposal	• Cargo and passenger handling • Pilotage and towage • Line handling • Facilities security, maintenance, and repair • Marketing of operations • Waste disposal • Landside and berth capital investment

Source: drawn by the author based on Brooks (2004, p. 172).

On the other hand, Baltazar and Brooks (2001) proposed a port devolution matrix as shown in Table 2-4. Their approach has quite different characteristics from Baird's model in that it independently categorizes regulatory functions from port functions and distinguishes operations specifically rather than as utilities. In addition, they do not divide each column horizontally among activities because they understand that the responsibility distribution is different between countries where a port is located. Brooks and Cullinane (2006c) proposed five types[13] of devolution in port governance which has taken places in many countries globally with Baird's model and the WBPRTK model applied.

2.3.2.2 Stakeholder approaches

Notteboom and Winkelmans (2002) argued that stakeholders and relations management should be reflected in the concept of port governance in order to promote the competitiveness of ports in the global logistics chains[14]. In addition, Notteboom and Rodrigue (2005) argued that the PA needs to approach the port governance in the new sight in order to adapt the changing environment that port-related activities are getting connected with land logistics and inland distribution activities. On the other hand, De Langen (2006) insisted that a stakeholder management approach is useful to understand the competitiveness and performance of a port as a cluster which various but related economic actors are located in. He argued that the term 'port governance' should be distinguished, as the cluster governance, from the PA governance which is corporate governance[15]. Verhoeven (2010) proposed the hypothetical typology of port governance that community manager is added as a function of the PA[16] as reflecting the trend that managing interests of various stakeholders are getting important as key factors of port competitiveness. As he mentioned, the roles as a stakeholder manager are often beyond both its responsibility under the PA-related law and its objective. This research approach can be understood as the result reflecting the trends in practice that port-related activities are integrated vertically in the global logistics networks and connected horizontally beyond

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[13] These five devolution types are

- Central government owned with central government management and control.
- Government owned but management and control are decentralized to a local government body.
- Government owned (federal, regional or municipal) but managed and controlled by a corporatized entity.
- Government owned but managed by a private sector entity via a concession or lease arrangement, or owned and managed via a public-private partnership agreement.
- Fully privately owned, managed and controlled.

[14] They proposed that the PA should manage the stakeholders and invest capital assets outside of the port area because port-related activities are getting embedded in the logistics chain with land transport and inland distribution centres connected closely.

[15] The PA governance is much more related governance issues such as shareholder-related issues, structure of the board of governors and corporate social responsibility.

[16] The PA is centred in port governance after devolving process of government's port-related authority and responsibility during the 1990s and the 2000s. As a result, port authorities, as an independent entity, are the focal point of criticism from societal interests such as local government, NGOs and citizens for negative externalities related to port-related activities even if these are not always controlled within the direct responsibility of port authorities (Verhoeven, 2010). By these reasons, he put port authorities in the centre of port governance instead of national and/or regional government.

port area or local jurisdiction. As evaluated by Wang et al. (2004), this approach is properly focusing on the procedural aspects that port authorities are attaining consensus among various stakeholders but not considering characteristics of societal and political cultures.

According to Freeman (1984) cited in Freeman and McVea (2001), stakeholders are defined as ‘any group or individual who is affected by or can affect the achievement of an organization’s objectives.’ Based on the definition of Freeman (1984), De Langen (2006) understood port as the cluster who have various stakeholders and argued how stakeholders in a port could be categorized. Many research in port studies follows the similar approach to De Langen (2006) in the point of focusing on classifying the stakeholders without defining the definition except for Notteboom and Winkelmans (2002). As cited in Notteboom et al. (2015, p. 229), they defined stakeholders in a port setting as ‘any individual or group of the person holding a legitimate interest, or being affected by port actions or inaction’.

Even though following the same definition of Freeman (1984) and Notteboom and Winkelmans (2002), a number of research show that classifications of stakeholders are different among researchers due to the research objectives (Fleming, 1987, De Langen, 2006, Lam et al., 2013, Notteboom et al., 2015). In other words, the classifications of stakeholders are mainly influenced by the angle of looking at a port; for instance, port as a part of its city, port as a component of the transport network, and port as an industrial cluster.

First of all, port stakeholders are classified in the sight of a part of its city which is based on geography. According to Fleming (1987), geographers had interests in understanding the seaport community (Brint, 2001, p. 8)[17] to understand the distribution of port-related services whether considering outside port district or not. He listed the entities of port-related activities on and outside the waterfront, focused on the critical mind, ‘who locates where and who owns what’ (Fleming, 1987, p. 336).

Secondly, port stakeholders have been grouped in the sight that a port is a component of transport networks and/or logistics chains based on management. As cited in Notteboom et al. (2015), Notteboom and Winkelmans (2002), suggest the classification[18] of stakeholders, mainly focused on the PA. Reflecting the research trend in Europe that PAs are centred in port governance after

[17] Fleming (1987) did not define the term of ‘community’ because he regarded the port community as a port-related part of urban community. According to Brint (2001), the community can be defined as ‘aggregates of people who share common activities and/or beliefs and who are bound together *principally* by relations of affect, loyalty, common values, and/or personal concern; i.e., interest in the personalities and life events)

[18] They categorize stakeholders into internal stakeholders and external stakeholders. The former are employee, board members, and shareholders of the PA. The latter can be divided into three groups: public policy makers at the national level and the regional level; market players such as terminal operator, land transport corporate, shipper, freight forward, etc.; community group such as regional residents, customers, tax payers, non-government organisation (NGO), and press.

devolving the authority of the central and local governments, they argue that the PA has played a critical role of managing stakeholders in a port. They put heavy stresses on the enlargement of the existing spatial boundary with regard to the PAs' port governance, adapting the environmental changes of logistics networks; intensifying vertical integration and overwhelming horizontal cooperation. Rooted in the same insight of Notteboom and Winkelmans (2002), Notteboom et al. (2015) suggest updated stakeholder categories[19] reflecting the various classifications of previous research such as Moglia et al. (2003), Henesey et al. (2003), and Dooms et al. (2013). They argue that stakeholders are various and influential whether they are related directly to port-related activities or not and the relationships among stakeholders is changing to be multi-directional.

Lastly, stakeholders in a port can be understood as individuals and groups of persons who are related to port-related activities economically and socially, based on the insight that a port is a kind of a cluster in which various stakeholders are agglomerating (De Langen, 2006, De Langen and Haezendonck, 2012). De Langen (2004, p. 210) defined a cluster[20] as `a population of geographically concentrated and mutually related business units, associations and public (private) organizations centred around a distinctive economic specialization'. Based on this definition, De Langen (2006) supplies eight categories of stakeholders[21] as depicting the interests, source of influence and indicators of influence respectively. Furthermore, De Langen and Haezendonck (2012) distinguish the roles of a port as an economic cluster from the ones as a node of transport and clarify the activities, through analysing forward and backward linkages, as dividing port-related activities into five categories: cargo handling, transport, logistics, manufacturing and trade. On the other hand, Lam (2011) suggests the classification[22] of port stakeholders focused on the value-driven chain based on the sight that a port is a key component of global supply chains. In addition, Lam et al. (2013) categorize stakeholders at the level of port clusters into six groups: terminals, employees, shipping companies, forwarders, government and community.

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[19] Stakeholder categories: shareholders of the PA, financial community, employees and labour unions, concessionaries, port users, carriers, passengers, port service providers, local community and societal groups of interest, and regulators

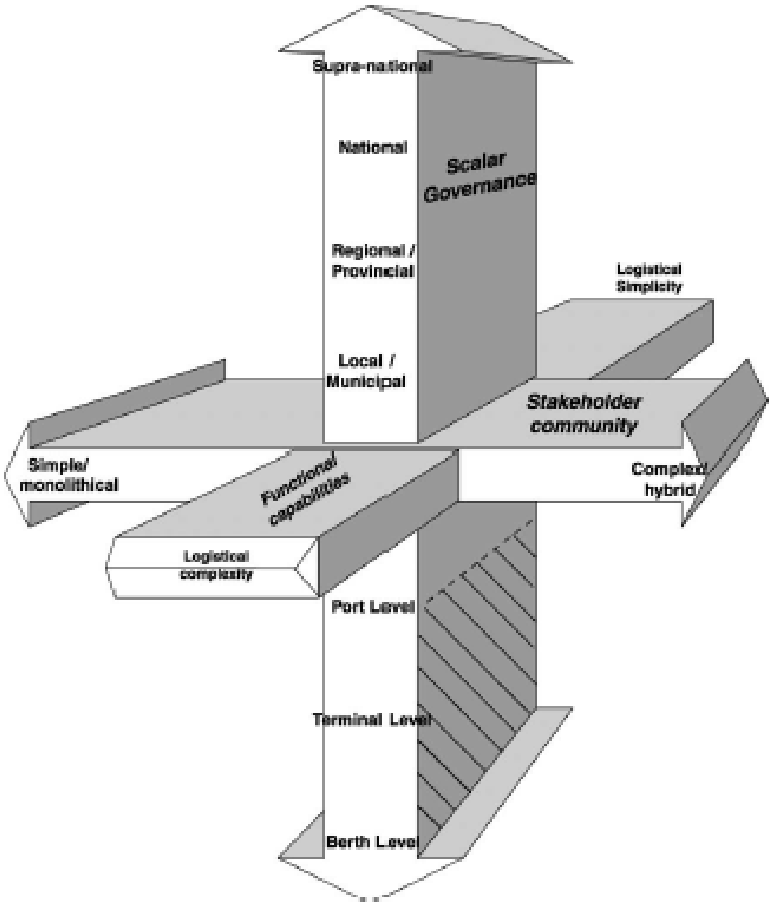
[20] This definition has five characteristics with consideration needed.

- Firstly, a cluster is a population, not an entity so the internal heterogeneity of clusters should be taken into account.
- Secondly, a cluster is geographically concentrated so it is different from networks.
- Thirdly, the cluster population consists of business units, associations, public-private organizations, and public organizations.
- Fourthly, a cluster is `centred around' a particular economic specialization, that can be regarded as the `core' of the cluster.
- Lastly, a cluster consists of business units and associations that are a part of, or relatively strongly related to, the core of the cluster economically and socially.

[21] Eight categories: transport firms (including terminal operators), port labour, local port-related manufacturing industries, end users of ports, local environmental groups, local residents, local and regional government, and national government.

[22] Stakeholder categories: the government, shipping companies, terminal operators, shippers, logistics service providers, and parties in related and supporting industries

Figure 2-7 A three-dimensional model of port governance



Source: Wang et al. (2004)

2.3.2.3 Comprehensive approaches

Wang and Slack (2002) proposed the broader governance concept, based on the social sciences, which could include social and cultural values in order to understand the characteristics of port development procedure in China. According to Wang et al. (2004, p. 238), their insight is in the line of Stoker[23] (1998) who stressed 'the networked interdependence of different actors and sectors in a given society'. In addition, they argued that power relations are influencing port-related policies both internally and externally as an operational and political entity. As shown in Figure 2-7, they suggest the adapted framework consisted of three axes such as spatial-jurisdictional scales, stakeholder community and logistical capabilities. The first axis represents how the authority and the responsibility are distributed by the level of spatial range. The second one relates to various issues

[23] Stoker's 'five propositions' with regard to governance are

- a set of institutions and actors that are drawn from but also beyond government,
- the blurring of boundaries and responsibilities for tackling social and economic issues,
- power dependence involved in the relationships between institutions involved in collective action,
- autonomous self-governing networks of actors,
- the capacity to get things done which does not necessarily rest on the power of governments to command or use their authority.

with regard to the participants in the supply chains; for example, who the participants are, what the relationship and business networks are, and what the cultural interfaces for foreign participants are. The last one reflects the trend that the port-related activities are increasingly related to or embedded in the global supply chains. Furthermore, Lee and Lam (2017, p. 507) argue that 'port governance would be understood in the context of structural changes of the overall systems' based on the insight that 'a port is a kind of organic system in a national socio-economic-political system as well as the globalised economic system.'

As mentioned by Wang and Slack (2002), this approach puts the stress on comprehensively understanding of port governance structure in a specific country rather than comparatively studying among countries. In addition, this approach methodologically has the strength in the point of understanding the characteristics of an individual port governance at the level of the regional and/or national economy rather than scrutinizing the ones at the level of a terminal or comparatively understanding the ones between or among countries (Wang et al., 2004).

2.3.3 Summary

As discussed above, port governance studies started from understanding the effects of the changed ownership of port facilities after privatization. As well, they have evolved from classifying the responsibility distributions to the direction to clarifying the relational roles of the port authorities even including managing various stakeholders. There is no need to say that understanding of the socio-economic-political system is necessary. Both port governance and port stakeholder related discourse have been quite vivid but are still short of the academic consensus with regard to the classification of port stakeholders as well as the definition of port governance and port community. Nevertheless, it is not difficult to clarify several trends over time with regards to port governance and stakeholder management in the sight of dynamic perspective.

First of all, the key point in port governance discourse has moved from who owns what to who plays what role and takes what responsibility (Baltazar and Brooks, 2006, De Langen, 2006). As a result, stakeholder related studies have been hot fields as the fourth function in port governance discourse due to the functional changes of ports in global logistics networks and global supply chains (Verhoeven, 2010). On the other hand, it is because port authorities have not only been under direct and/or indirect pressure from more various stakeholders (Dooms et al., 2013), including the influence from the socio-economic system, but also increasingly faced with the dilemma of how to reconcile the competing and/or conflicting claims of expanding stakeholders (Notteboom et al., 2015).

Secondly, port governance studies have evolved to become a multi-dimensional research area. In the 1990s and early the 2000s, most research put the stress on the relational perspective between public and private in terms of the ownership of port facilities and the responsibility distribution. However, a number of research studies have developed the port governance discourse with the different dimensional perspective focused such as the functional aspect (Notteboom and Winkelmans, 2002, De Langen, 2006, De Langen and Haezendonck, 2012), the spatial scope (Notteboom and Winkelmans, 2002, Verhoeven, 2010), and the hierarchical aspect of the governance structure (Wang and Slack, 2002). As a result, port governance studies should be approached considering the three dimensional aspects: the scalar governance (hierarchical criteria and spatial scope), the functional capabilities (functional scope), and the stakeholder community (Wang et al., 2004), and based on even the understanding of a national socio-economic-political systems (Lee and Lam, 2017). In conclusion, how to analyse the salience in the governance of a specific port is up to the research objective.

Lastly, port stakeholder groups are expanding and their inter-relationships have changed over time. According to Notteboom et al. (2015), the most influential stakeholder groups have changed and new stakeholder groups emerge as societal interests vary over time. In the case of the port of Rotterdam, some categories like financial community, concessionaires and carriers experienced the reduction in the salience of port stakeholders between 2000 and 2012. On the contrary, the other categories including employees, passengers, local community and regulators have increased their influence on different stakeholders.

This study is aiming mainly to examine if the surrounding changes such as the intensification of the functional integration and the spatial enlargement influence the economic contribution of the port-related activities. For this reason, the overview of Korean port governance will focus on briefly understanding the characteristics at the port and/or regional level rather than at the terminal level. The overview will be introduced in the next chapter as a background for understanding the features of the Korean four major ports. Meanwhile, the reason that this study looks over the characteristics of port governance mainly at the level of individual port and regional economy will briefly be introduced in the sub-section of port impact study.

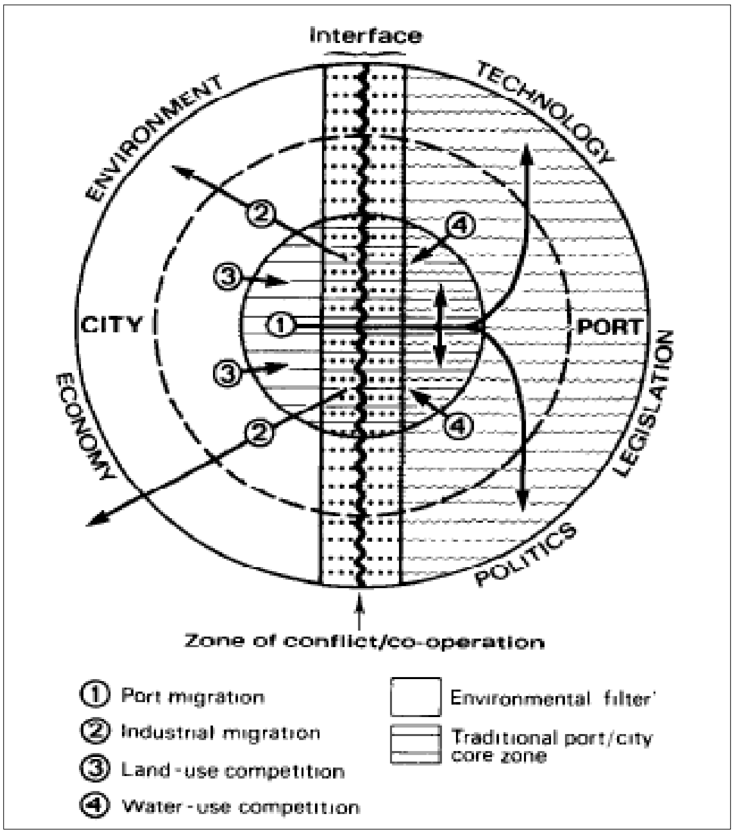
2.4 Port-city Interaction

Even though the ‘port city’ often appears in the port literature, it is quite difficult to define it as a single unit. As such, the study scope of the port-city depends on the geographical level: the port-city interface and a regional area (port range, urban, country). In addition, the interaction of the port and the city conventionally is approached through two lens of the spatial relationship and the economic impacts (Ducruet and Jeong, 2005). In this part, the literature review is implemented mainly focusing on the port-city interface (waterfront level) and port-city relationship (urban level) but not the impact of the port on the regional economy, discussed in the next sub-section.

2.4.1 The definition of the interface

Hayuth (1982b) suggested the concept of the port–urban interface as an area in transition which was focusing both the spatial system and the ecological system in order to overcome the limitations of various case studies from the world (Hoyle and Pinder, 1980). On the other hand, Hoyle (1989) expanded the concept from a geographical line or an area in transition between the port district and the urban zone to an interactive economic system or an integration area in transport terms and an area of conflicts in the policy formulation and implementation.

Figure 2-8 Waterfront redevelopment: factors and trends



Source: Hoyle (1989, p. 432).

As a result, the concept can be expressed as a diagram in Figure 2-8. Meanwhile, Hoyle and Pinder (1992) refer to the urban planning perspectives. This is evaluated to be a cornerstone in the frame of the port redevelopment, although it does not explain both what leads and what takes place in the port redevelopment (McManus, 2007).

2.4.2 The evolution of separation

Hayuth (1982b) suggests that the port-city interface moved to the outskirts due to the changes in the transportation technology and the various pollutions. Since then, there are various approaches to explain the port-city interface by applying different lens based on the inception of Bird (1963). Hoyle (1989) proposed the pattern of the port-city interface in the sight of the interrelation between a port and its city over time (see the first phase to the fifth phase in Figure 2-9). His model consists of five steps: the primitive city port, the expanding city port, the modern industrial city port, the retreat from the waterfront and the redevelopment of the waterfront. As shown by the name of each step, he regards the technical changes both in the transport networks and in the economic system as the main factor to bring the change in the port-city interface. Furthermore, he insists that a special consideration with regard to the waterfront regeneration should be taken since there are intricately interwoven interests.

On another hand, the efforts to clarify the causes of the port-city separation expanded the factors beyond the ones rooted in the transport networks by the 1990s. Murphey (1989) suggests that the scale of a port and its regional economy could influence the functional and spatial relationship between the port and the city. In this line, Ducruet (2011) proposes that the urban economy becomes less and less related to the port activities while reaching a final stage of the autonomy as it develops new additional functions. Furthermore, he suggests that the economic evolution of the port-city would better be examined by looking at its overall ability rather than the port itself (Murphey, 1988), although the physical site may have influenced the decline of some ports rather than other factors (Jackson, 1983).

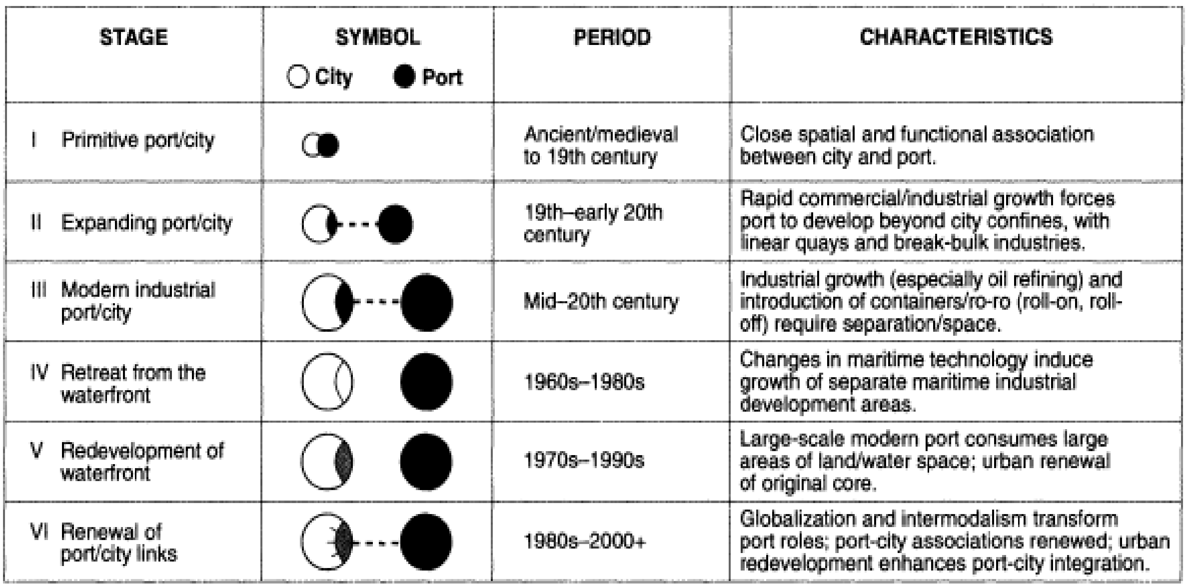
On the other hand, Norcliffe et al. (1996) perceive both the technical changes in the transport networks and the structural shifts in the regional economy as the motivation of the waterfront retreat. He focused on the economic shift of ‘Fordism to post-Fordism’: especially, the shift from the production-centric economy to the culture economies of consumption (Sack, 1988), the socio-cultural transition of ‘modernism to post-modernism’ and the values of the waterfront as the position goods. Based on this insight, the retreat of the waterfront, in which the consumption and the leisure activities replaced the former industries, is implicitly recognised as one way to maximize the social value of the waterfront (Ducruet, 2011). Meanwhile, Olivier and Slack (2006) mention that the economic shift had “only a marginal impact on port geography” (p. 1416) due to an acknowledged weakness in the empirical evidence. As well, this approach has been in the debates about the re-usage of the waterfront; on the opposite side, there is the insistence that the derelict area in old port should be relocated or redeveloped for port-related activities (Charlier, 2013)

2.4.3 The new trends from different viewpoints

Some researchers supply the case studies, in the line of port-city interface separation, to explain the procedure that the commercial or industrial ports in Europe and North America. These ports, which had been developed through passing the ages of mercantilism and industrialisation since the middle ages, experienced the changes both of moving spatially from the originated and city-central area to the peripheral area and of contributing economically their own city less than before. These ports, located in the global cities such as Boston, San Francisco, Barcelona, London, New York, Toronto, Rotterdam, Sydney, etc., had experienced or been experiencing the redevelopment projects in the old port area (Hoyle, 2000a, Hoyle, 2001). This approach is applied to the port redevelopment issues all over the world; from the developed to the developing, by the 1990s when a critical study began to appear in the port studies (Wiegmans and Louw, 2011).

However, this approach faces two points of criticisms. One is that the port redevelopment could make the relationship between the port and the city more closely than before due to the characteristics of containerisation (Hoyle, 2000a, Hoyle, 2001); especially, in terms of the urban planning perspective (Wiegmans and Louw, 2011). The other is that some ports in East Asia have shown the different path in terms of the change of the port-city interface (Wang, 1998, Ducruet and Jeong, 2005, Lee and Song, 2005).

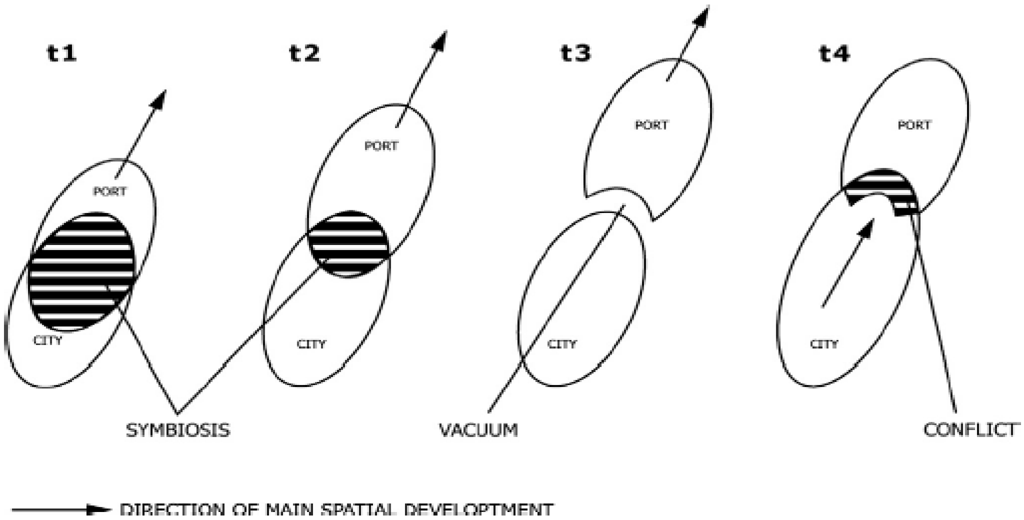
Figure 2-9 Six stage evolution of the port-city interrelationship



STAGE	SYMBOL ○ City ● Port	PERIOD	CHARACTERISTICS
I Primitive port/city		Ancient/medieval to 19th century	Close spatial and functional association between city and port.
II Expanding port/city		19th–early 20th century	Rapid commercial/industrial growth forces port to develop beyond city confines, with linear quays and break-bulk industries.
III Modern industrial port/city		Mid–20th century	Industrial growth (especially oil refining) and introduction of containers/ro-ro (roll-on, roll-off) require separation/space.
IV Retreat from the waterfront		1960s–1980s	Changes in maritime technology induce growth of separate maritime industrial development areas.
V Redevelopment of waterfront		1970s–1990s	Large-scale modern port consumes large areas of land/water space; urban renewal of original core.
VI Renewal of port/city links		1980s–2000+	Globalization and intermodalism transform port roles; port-city associations renewed; urban redevelopment enhances port-city integration.

Source: Hoyle (2000a, p. 405).

Figure 2-10 Spatial model for the port-city interface



Source: Wiegmans and Louw (2011, p. 528).

According to Ducruet (2011), Charlier (1992) suggested that the derelict area in the old port would better be re-used for port-related activities, based on the idea of the port life-cycle. Hoyle (2000a), reflecting the epistemological changes after his work (1989), suggests the revised model of adding the sixth stage from the 1980s to the 2000s as shown in Figure 2-11. He insists that the renewal of the port-city links, which the city is required to support the port in the functional and spatial aspects, occurs due to the globalisation and the inter-modalism in the transport networks. In the recent, Wiegmans and Louw (2011) suggest the new topology model by revising the work of Norrcliffe (1996). The model in Figure 2-10 implies that the interface is considered as the conflicting zone in the aspect of the urban planning since the port and the city compete for the usage of the short space.

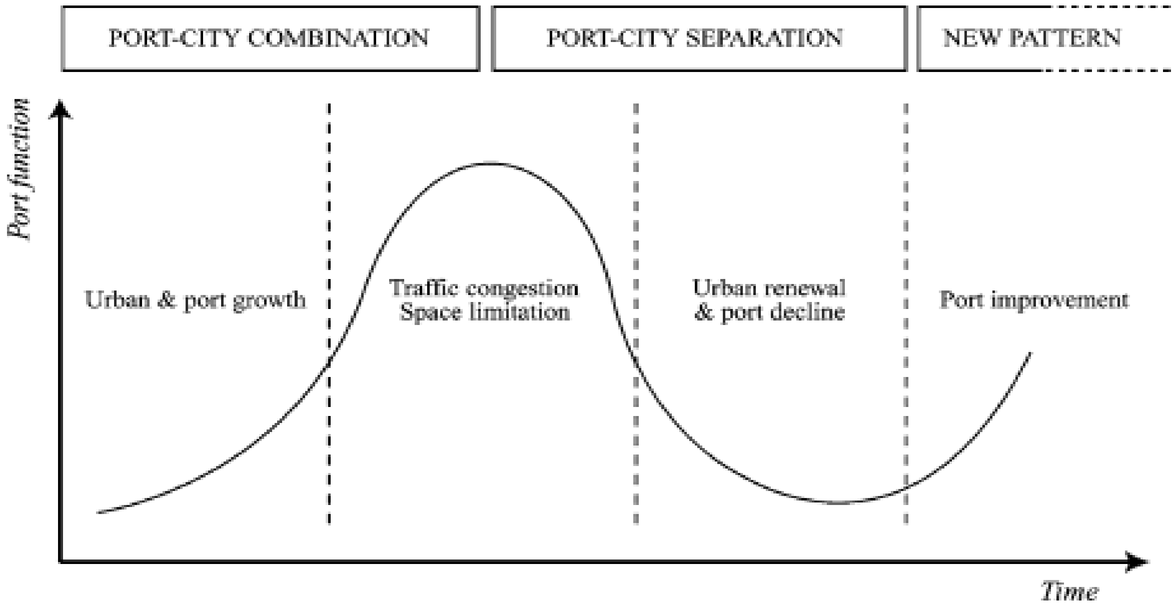
The other criticism is that the economic relationship and the interface between the port and the city should be understood in the different context between in the western countries and in the Asian countries (Wang, 1998, Lee and Song, 2005). Wang (1998), who triggered the debates, suggests that the multi-national companies move their production base and/or rearrange their global supply chains centred on the countries and the ports in East Asia. Furthermore, some ports in East Asia have shown the different path of strengthening the functional relationships in the sight of the port-city interface (Wang, 1998, Ducruet and Jeong, 2005). Specifically, the empirical study by Slack and Wang (2003) supports that the development pattern of the port in both Singapore and Hong Kong is consistent with the work of Wang (1998). In this line, Lee and Song (2005) propose that the port-city separation phenomenon is dwindling over time because the functional shift and spatial enlargement of the port require various functional supports from the city as shown in Figure 2-11. These results have the limitation in the point that they are derived from the empirical studies of the ports only of Singapore and Hong Kong, which are ranked in world top three in terms of the annual container freights and have the well-developed service industry related to the port (Lee and Song, 2005).

Figure 2-11 Evolution of port-city interface in a Western country and in Asia

WESTERN PORT CITY MODEL	Period	ASIAN HUB PORT CITY CONSOLIDATION MODEL
Primitive cityport Close spatial and functional association between city and port	Ancient-medieval to 19th century	**Fishing coastal village** Small community of natives practice self-sufficient local trade
Expanding cityport Rapid commercial and industrial growth forces port to develop beyond city confineswith linear quays and break-bulk industries	19th to early 20th century	**Colonial cityport** Dominant external interests develop both port and city for raw products exportation and geopolitical control
Modern industrial cityport Industrial growth (esp. oil refining) and introduction of Ro-Ro and container facilities requires separation and increased space	Mid-20th century	**Entrepot cityport** Trade expansion and entrepot function, modern port development from sea reclamation
Retreat from the waterfront Changes in maritime technology induce growth of separated maritime industrial development areas	1960s - 1980s	**Free trade port city** Export-led policy attracts industries using port facilities through tax-free procedures and low labor cost
Redevelopment of the waterfront Large-scale modern port consumes large areas of land and water space, urban renewal of original core	1970s - 1990s	**Hub port city** Increasing port productivity due to hub functions and territorial pressure close to the urban core
General port city Rising environmental concern for intermodal transport, city economy develops alike non-port cities	1990s - 2000s	**Global hub port city** Maintained port activity and new port building due to rising costs in the hub, possible hinterland expansion

Source: Lee et al. (2008, p. 380).

Figure 2-12 Logics of port-city spatial and functional evolution



Source: Ducruet and Lee (2006, p. 113).

2.4.4 Summary

"Pumain et al. (2009) pointed rightly at the marked differences in the trajectory of some port cities, which fluctuated according to the importance of the port for inserting the city into trade networks at different time periods" (Ducruet, 2011, p. 4). Indeed, this recognition dates back to Charlier (1992) and is in the line of the recognition that the port-city interface is so variable and intricate both spatially and over time that the social, economic and political characteristics should be considered, based on an appreciation of the interdependence (Hoyle, 2000a, Hoyle, 2001). In the line with this approach, the various factors of multiplying the uncertainty in the sight of the relationship of the port-city are suggested continuously; especially, the behaviour of the stakeholders (Daamen, 2007), the urban planning (Wiegmans and Louw, 2011), and the institutions and the role of the port authority (Daamen and Vries, 2013). On the other hand, Ducruet and Lee (2006), as shown in Figure 2-12, suggest that the port functions as a whole, including indirect port-related activities such as maritime insurance, ship management, could fluctuate over time, although the port-city interface changes according to the multiple factors.

This study focuses on understanding the economic contribution of the port-related activities under the surrounding changes such as the intensification of the functional integration and the spatial enlargement. For this reason, this study looks at the relationship between the port and the city at the comprehensive interaction, suggested by Ducruet and Lee (2006), rather than at the interface, focusing on the spatial concept.

2.5 Port Impact Study

It is nowadays widely accepted that the ports contribute the economic growth of the port cities (Fujita and Mori, 1996) and cause the negative effect such as heavy congestion and severe pollution (Grobar, 2008). In addition, the positive impact tends to move away from the port city to an adjacent region and/or to other regions in the country (Benacchio and Musso, 2001). The results in port impact study (PIS) may be in common to stimulate and justify the budget allocation for port development from the central or municipal government (Danielis and Gregori, 2013). Especially, the contribution of port activities like job creation and value-added are needed to "maintain and strengthen the societal acceptance of seaport activities" (Dooms et al., 2015, p. 460).

Nevertheless, the PIS is increasingly used to communicate the performance of the port development or port-related activities both because a number of stakeholders require the quantitative performance and because there is no rivalry methodology in terms of quantitative assessment (Dooms et al., 2015). For this reason, this study introduces the literature review of the PIS focused on the methodology and the empirical analyses in order to clarify what gaps exist between the PIS and the port development studies discussed in the previous section.

2.5.1 Overviews of PIS

2.5.1.1 Aims of PIS

Most PIS focus on explaining the justification of port development to stakeholders or decision-makers by quantifying the economic effects of port development (Dooms et al., 2015, Benacchio and Musso, 2001). However, looking at the aims in more specific, the sub-goals can generally be categorized into three groups as below (Benacchio and Musso, 2001, p. 28):

- Understand the economic relationships between the port and the regional economy in the qualitative and/or quantitative sights;
- Measure the regional economic impact generated in and derived from of the ports in a given time period or over time;
- Quantify the economic effects derived from the investments in new infrastructure by operating a simulation model.

At a glance, the three sub-goals are based on the clearly different viewpoints: namely, cross-sectional sight and longitudinal aspect. The first and the second sub-goals can be reached by examining the interrelation between industrial sectors but the last one can be accomplished by estimating the economic effects over time by applying the longitudinal research methodology. As a result, the goal of the research affects to select the research methodology in PIS:

2.5.1.2 Assessment of port economic impact

What is the economic impact of ports? This question is basically in the area of subjectivity with two different issues related: what the best proxy is and what the good boundary is. As a result, the definition of the economic impact of ports is converted to selecting of the variable as a proxy and distinguishing of the industrial sectors affected by the ports (Benacchio and Musso, 2001). In addition, the latter issue is closely related to the former issue.

If the employment is taken as a *proxy*, some partitions of port economic impact can be applied by Davis (1983) as below:

- *The direct effects*: the employment of all activities necessary for the operation of the port and other activities related to the outgoing and incoming shipment of the goods and passengers;
- *The indirect effects*: the employment of all economic activities developed in the port region and dependent on the primary activities through a technical relationship of the buying and selling of goods and/or services;
- *The induced effects*: the employment of all activities that also take place in the wide port-region and that depend on the direct and indirect effects through "consumption" linkages.

This classification has been applied in the following studies such as Yochum and Agarwal (1988), Gretton (2013), Artal-Tur et al. (2015): even in the research with the IO analysis or just the IO table applied.[24] Nevertheless, the relationship of various activities may vary from port to port due to the different orientation of the activities and the absence of consensus as to what activities are truly necessary (Benacchio et al., 2001). As a result, the classification of the port economic impact is likely to be different by research according to the research methodology.

On the other hand, the *GVA(Gross Value-added)* or the *GDP(Gross Domestic Product)* created by the port are regarded as the best variable for assessing the role of ports as an engine of the regional economic growth for the recent decade (Benacchio and Musso, 2001). Meanwhile, the issue of the boundary is likely to depend on the research methodology: the above classification in the case of the IO analysis (Artal-Tur et al., 2015, Danielis and Gregori, 2013) but the subjective criteria in the case of the regression analysis (Song and van Geenhuizen, 2014, Deng et al., 2013).

The GVA has the strengths as a proxy for the port economic impact in several aspects. Firstly, the concept of the GVA, in principle, is the best proxy to comprehensively represent the amount by the

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[24] Castro-millan (1998) distinguished the economic impact of ports into two types:

- The *primary* (or direct) impact: all activities necessary for the operation and use of the port facilities;
- The *secondary* (or indirect) impact: all the economic activities of the area of influence of the port (local community and hinterland) that economically depend on primary activities.

monetary value of the social wealth produced by ports (Benacchio et al., 2001).[25] Namely, the employment is a better indicator in the sight of a typical local input, while the GVA is focused on the whole wealth, as an output, produced and induced by the port. Secondly, the port as an industrial sector is not labour-intensive any more under the pressure of capital deepening in the global logistics networks (Jung, 2011). In addition, the port activities have faced the surrounding changes to connect horizontally and integrate vertically in the transport network or in the global logistics chains (Monios and Wilmsmeier, 2012a). The above changes mean that the employment is getting weaker as a proxy for the economic impact due to the input variable. Lastly, in the sight of the research methodology, the more the econometric analysis is applied in PISs, the more the GVA are getting prevailing (Park and Seo, 2016, Bottasso et al., 2013). It can be said to result from that the port variables are generally applied as the independent variable and that the GVA generally is likely to enhance the power of the regression model compared to the employment.

In conclusion, the PISs have focused on the empirical analysis by selecting the appropriate variable and the proper boundary of the port economic impacts according to the research objective rather than the theoretical discussion with regard to the definition (García and López, 2004). This is due to not only the limitation of defining the economic impact but also the selection of considering the difficulties in practice such as data collection.

2.5.1.3 Main effects of ports

The traditional view in the port economic impact study is that the ports contribute to the growth of the regional economies by facilitating the convenience and the cost reduction in the transport networks (Fujita and Mori, 1996) and by centralizing the city compared to the periphery regions (Meyer, 1999). Fujita and Mori (1996) suggest that the economic activities in the port city have a comparative advantage thanks to the better accessibility with low transport cost. In addition, the presence of the port contributes to the growth of the regional economies by supporting various activities in the coastal industrial areas in order to avoid high land transport costs by sea (Musso et al., 2000). A large number of PIS suggest that the ports supply economic developments for the port regions by creating various economic effects: strong externalities, economies of scale, and agglomeration effects (Coppens et al., 2007, Danielis and Gregori, 2013, Bottasso et al., 2014). On the other hand, Meyer (1999) suggests that the port regions have the chance to develop their economies by attracting the population into the urbanized area so that the port area is likely to evolve to a huge urban centre (Meyer, 1999).

[25] It is quite clear that the ports with the industrial and logistic linkages established are able to produce (and potentially extract at a local level) a wider economic rent from direct and indirect port activities.

On the opposite side, a huge body of the research argues that the ports bring the negative effects or the trade-offs with the port cities mainly. The ports trigger and support the development of the port cities based on the better accessibility, but also have the more side effects of conflicting in the land use and exaggerating the traffic congestion and the environmental problems gradually over time (Benacchio and Musso, 2001). In the sight of the economic impact, the contribution of the ports on the regional economies is in the decreasing trend under the influence of containerization (Vallega, 1996) and port competition and the formation of hub & spokes system (Ducruet and Lee, 2006). In addition, the negative relationship was formed between the port cargo traffic and the population of the city after the 1990s (Ducruet, 2009). From the viewpoint of the employment, the ports have been in the declining trend in European port cities. This is due to the weakening of the manufacturing industry's advantage in terms of ports, (Damesick, 1986, Gripaios, 1999). On the other hand, in the spatial aspect, some research argue that the ports derive the negative impacts on the urbanized area adjacent the port district by reducing the attractiveness of the area due to the heavy congestion, the severe pollution, and the deterioration of the coastal landscape, etc. (McCalla, 1999, Grobar, 2008).

On the other hand, the contribution of the port to the local economy is likely to depend on the efficiency of the port. Namely, the more efficient ports experience an increase in economic benefits by attracting the more cargo, while the less efficient ports have the less or negative effect of isolating the area (Haddad et al., 2006). Especially, in the Asian region where the manufacturing industry is continuing to develop, the support effect of the port on the urban economy is relatively large. Meanwhile, the relationship between the port and the city has changed over time (Norcliffe et al., 1996). In this line, it can be said that the economic impact of ports is mainly depending on the size of the port, the relationship with the other competing ports, and the industrial structure in the regional economy, etc.

2.5.2 Main Methodologies of PIS

According to Benacchio et al. (2001), port economic impact studies can be classified, in the sight of research methodology, into 6 categories: rough guess methods including ad hoc survey methods, models of port demand, the economic base approach, Keynesian Income-Expenditure approach (so-called multiplier approach), Input-Output approach, and Location Quotient. Firstly, rough guess methods represent for all port impact studies without any specified methodology applied. Benacchio et al. (2001) evaluated that this approach is usually applied to support some political aims such as the emphasis on the port benefits but does not provide transparency on examination.

Secondly, the economic base approach is based on the assumption that regional income mainly depends on the exports so that the economic base multiplier represents the relationship between the changes in income and the changes in exports. According to Benacchio et al. (2001), the application of this approach in port impact studies raised a huge of criticism due to the strong assumption.[26]

Thirdly, the Keynesian Income-Expenditure approach, so-called multiplier approach, has been introduced to examine the secondary impacts derived from port activities (Kinsey, 1981). In the income-expenditure multiplier, the critical value lies in the marginal propensity of consuming goods produced internally. According to Benacchio and Musso (2001), this approach is criticized to provide just one multiplier for calculating of the induced effect and not to supply any information with regard to the technical and/or economic interrelations between different sectors.

Fourthly, DeSalvo (1994) and DeSalvo and Fuller (1995) suggest the microeconomic methodology with the concept of social savings[27] applied, as shown in Appendix 3, in order to examine the economic impact of ports. As well, they explained the procedure that a shock in both exports and imports results in the decrease in direct employment and the reduction in indirect employment; specifically, by increasing sale prices as well as transportation costs and finally decreasing the demand of the products (see the former for the detailed).

Fifthly, the IO approach is regarded as one of the most valuable and popular methodologies for port impact studies (Yochum and Agarwal, 1987, Coppens et al., 2007). As discussed in Appendix 3, the quantities of input and output for a given period are entered into an input-output matrix within and across various sectors of an economy. Then, the impact of the port-related sectors can be computed with a breakdown level depending on the matrix framework (Gripaios and Gripaios, 1995). This approach is often applied in empirical studies as shown in Table 2-5.

Lastly, the Location Quotient (LQ), which applied in port impact study by Musso et al. (1999), is a technique widely used in economic geography and regional economics to examine the degree what industries in some region are concentrated (Miller et al., 1991). As well, the approach is quite useful for policymakers or researches to evaluate the growth of regional economies by regional base multipliers. The approach was used to estimate the port's impact in local employment assumed as the employment that can be attributed to the port within the *direct, indirect* and *induced* impact (Benacchio et al., 2001).

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[26] The model has been criticized for three limitation as below (Benacchio et al., 2001):

- It considers as a non-basic (or endogenous) sector all activities related to the flows of imports;
- The model only provide an aggregate multiplier (a substantial increase in exports of a determined good has exactly the same multiplying effect as an equal increase in exports of a different good);
- The model mainly computes the induced effects without offering satisfactory assessment of the indirect effects.

[27] The conceptual framework is in line with social savings in the point of calculating the impact based on the cargo volumes transshipped by the port and the price elasticity of the demand for imports and exports channeled through that port.

Despite the methodological classification of Benacchio et al. (2001), the approaches applied in the empirical studies are not very varied. The economic base approach and the multiplier approach are the methodologies that had been applied before the 1990s when the port impact study began to increase rapidly. Meanwhile, in the case of the LQ, it is not easy to find a follow-up study of Musso et al. (2000) and Musso et al. (1999) who introduced the LQ in port impact studies. It can be evaluated to reflect the trend that the port impact studies are highly dependent on a few methodologies in terms of the efficiency in the application of the methodology and the effectiveness of the results.

For this reason, this study examines the trend of the empirical analyses in the port impact studies by comparing key empirical papers published over the last three decades in the following sub-section.

2.5.3 Some features in empirical analyses

The major empirical studies published for the last three decades are shown in Table 2-5. At a glance, the table implies that the port impact study is experiencing many changes in the sight of the methodology and the point of view. On one hand, from the viewpoint of the methodology, regardless of the time, it is the IO analysis that has been applied the most lasting in the port impact studies. As well, it is very meaningful that some research conduct the IO analysis by applying the Regional IO table but not deriving the inter-industry linkage at a regional economy from the Nation IO table (Coppens et al., 2007, Artal-Tur et al., 2015). On another hand, the application of the regression analysis in the port impact studies has been rapidly increasing since the 2000s and indicates that it becomes a strand that can be compared to the IO analysis. In particular, the application of the regression analysis for the cross-sectional time-series data (panel data) has increased rapidly during the 2010s (Shan et al., 2014, Song and van Geenhuizen, 2014, Bottasso et al., 2014, Park and Seo, 2016). On the other hand, it can be concluded that the other methodologies such as the multiplier approach, the LQ, and the Spatial Computing General Equilibrium (SCGE) are intermittently and irregularly applied under the trend that the above two methodologies play an important role as a prevailing method in the port impact study

Secondly, from the viewpoint of research, the research focusing on whether or what extent ports and port activities contributes to the economic growth at the regional level appears to be increasingly dominant rather than at the national level. In particular, there are few studies of examining the economic effects of ports at the national economy except for Kawakami and Doi (2004) and Chang et al. (2014). In addition, just two empirical studies of Coppens et al. (2007) and Economics (2013) handle the economic effects of port activities at the national level as well as at the regional level.

Thirdly, from the viewpoint of the variable applied, it can be seen that the gross domestic product (GDP), the gross regional domestic product (GRDP) or the gross value-added (GVA) get adopted in

Table 2-5 Key empirical studies for economic impacts

Author	Methodology	Point of view	Key Variables	Data type	Research Scope	Key findings
Kinsey (1981)	Multiplier approach	Examining sectoral linkage at the regional level	Employment, wage and salary, turnover, throughput	Primary data by survey	Port of Liverpool, UK	Economic impact of the Port of Liverpool on the regional economy was declining under influence of the changes in the commodity movements and corgo-handling methods and competition with the other coast ports.
Yochum & Agarwal (1987)	Input-output analysis	Estimating the secondary impact at the regional level	Employment, income, tax revenue	Primary data by survey	Port of Hampton Roads, USA	Roughly 8 percent of the total economic impact of the port is attributable as the secondary impact to firms with such a linkage to the port.
Gripaios & Gripaios (1995)	Input-output analysis	Examining the impact at the local level	GDP, employment	Secondary data, Primary data by survey	Port of Plymouth, UK	Ports are not big employers of labour and are no longer the inter-related industrial complexes that ports once were.
Musso et al. (2000)	Location Quotient (A few versions)	Estimating the emoployment impact at the local level	Employment	Secondary data from the National Bureau of Statistics, Case study by survey	22 port cities and not-port regions, Italy	The employment impact of the port (1996) represents about 20% of total employment. The case study showed the decrease in the employment/ throughput ratio.
Kawakami & Doi (2003)	Regression analysis	Analysing the causal relationships at the national level	GDP, private capital, transport user cost, port capital	Secondary data from various organizations	Japan	The elasticity for GDP is comparatively higher than those in past studies and demonstrates the important role of port capital in the heavily trade-oriented economy of Japan
Zhang & Zhang (2005)	Regression analysis	Estimating the statistical relationship	Throughput, aggregate gross product value of industry, foreign direct investment	Secondary data from National Statistics Bureau	Guangdong Province, China	The complex positive feedback between FDI, regional economic growth, and container ports development heavily rely on the locan container ports.
Coppens et al. (2007)	Input-output analysis	Measuring the impact at a disaggregate level for national and regional economy	GVA, employment	Secondary data from Regional IO Table	Port of Antwerp, Belgium	The important links between freight forwarders and agents exist. The geographical analysis suggests the existence of major agglomerating effects in and around the port of Antwerp.
Ferrari et al. (2010)	Regression analysis (Cross-sectional data)	Estimating the impact of ports at the regional level	Employment, Throughput, Transport variables etc.	Secondary data from various organizations	Italy	Positive impact observed. The impact of port depends on the sector being considered.
Haddad et al. (2010)	Spatial Computable General Equilibrium (CGE)	Elucidating the mechanism to link trade barriers in the sight of costs at the national level	Transport costs	Secondary data from the Brazilian Statistics Bureau	27 states, Brazil	Improvement in port efficiency may generate greater bilateral trade and further displace the freights produced in the far regions.

Jung (2011)	Descriptive	Examining the economic relatioship between ports and port cities	Port throughput, economic indicators	Secondary data from various organizations	9 port regions, South Korea	No strong effect on production and value added inducement coefficient over 1990–2008. Port-city interface from economic perspective has been weakened during 1990s and 2000s in Korea.
Oxford Economics (2013)	Multiplier approach	Estimating the impact at national and regional economy	Employment, GVA, Contribution to Exchequer	Secondary data from various organizations	UK	Estimating the values of direct, indirect, and induced impact of the ports sector in 2011. Including the multiplier impacts affects the regional distribution.
Danielis & Gregori (2013)	Input-output analysis	Identifying the economic features of the port system at the regional level	Number of firm, revenue, value-added	Secondary data from the IO tabel Primary data by interviews	Friuli Venezia Giulia Region, Italy	The port system plays a relevant macroeconomic role in the region and is characterized by a high degree of openness from an economic, commercial and industrial point of view. The system is part of a larger territorial system.
Deng et al. (2013)	Structural Equation Modelling	Examining the relationship between ports and regional economies	Throughput, quay length, berths, VAS, GDP, per capita GDP etc.	Secondary data from 46 port authorities	Coastal regions, China	No significant positive effect of port demand and supply on regional economy. Value added activity has positive effect on regional economy.
Shan et al. (2014)	Regression analysis (Panel data)	Examining the impact of port activities at the regional level	GDP, GGDP, education, FDI, road, throughput etc.	Secondary data from various organizations	41 port cities, China	Significant positive effect on economic growth, consistent with theoretical predictions. Throughput of bigger ports is more significantly associated with local economy than smaller ports.
Bottasso et al. (2014)	Regression analysis (Panel data)	Examining the impact of port activities at the regional level	GDP, area, population, throughput, motorways etc.	Secondary data from various organizations	120 regions, 13 EU Countries	Ports tend to increase GDP of region where they are located. Ports also have large and positive spill-over on GDP of nearby regions.
Song & van Geenhuizen (2014)	Regression analysis (Panel data)	Estimating the output elasticity of port infrastructure at the regional level	GDP, investment in port, the share of manufacuring, road density etc.	Secondary data from various organizations	Port regions, China	The output elasticity of port investment is relatively low. Improving port efficiency is much more important than the increase of physical infrastructure only.
Chang et al. (2014)	Input-output analysis	Estimating the economic impact at the national level	95 different products and services	Secondary data from National Accounts	South Africa	Port activity is not dependent on other industry while other industries are more dependent on port activity.
Artal-Tur et al. (2015)	Input-output analysis	Estimating the economic impact at the regional level	GVA, employment, salary	Secondary data from the Regional IO Table	Port of Cartagena, Spain	The Port of Cartagena plays a growing and important macroeconomic role in the region thanks to the increase of the economic impact of the port in terms of GVA for the studied period.
Park and Seo (2016)	Regression analysis (Panel data)	Estimating the statistical relationship at the regional level	GDP, factors in production function, cargo throughput, container throughput, port investment etc.	Secondary data from various organizations	16 regions, South Korea	Port activities positively affect regional economic growth, while port investment indirectly leads to economic growth.

Source: compiled by the author based on the papers in the table.

more and more studies as a proxy for the economic impact of ports. In fact, the employment was applied as a proxy in the studies of Kinsey (1981), Yochum and Agarwal (1987) and Musso et al. (1999). However, in the 2010s, the case studies in which the GDP or the GVA is applied as a proxy are getting overwhelmingly: especially in the case of the regression analysis. This research trend can be interpreted as the reflection of the research implication that ports or port activities are getting capital-intensively more and more (Benacchio and Musso, 2001).

Lastly, with regard to the key findings, the results in the table are in line with the results discussed in the previous sub-section. On one hand, if ports contribute to the economic growth and whether the port impacts are positive or not are mainly affected by the country and the region in which or the variable with which the empirical study is conducted. The economic effect of ports on the regional economies has largely declined and has not been positive any more in the case of European countries such as the UK, Italy, and Belgium (Ferrari et al., 2010, Musso et al., 2000, Gripaios and Gripaios, 1995, Kinsey, 1981). Meanwhile, the ports in the developing countries such as China, Brazil and South Korea contribute significantly to the growth of regional economies (Park and Seo, 2016, Song and van Geenhuizen, 2014, Shan et al., 2014). On another hand, in terms of the variable, the studies show the tendency that the effects of the port activities are relatively low or almost non-existent when the employment is applied as a proxy of the economic growth, while the ones are relatively positive when the GDP or the GVA is applied. On the other hand, from the viewpoint of the research objective, most of the empirical studies focus on examining if or calculating what extent port activities contribute to the growth of the regional economies at a given point in time or for a given period. However, Jung (2011) suggests both if port activities contribute to the economic growth at the regional level and what changes in the economic contributions happened over time even though he applied a descriptive approach. This clearly suggests what is necessary in the point of the research methodology in order to meet the research objectives of this study.

2.5.4 Summary

This study discusses the theoretical features and the empirical aspects in port impact studies. As a result, this study clearly shows that the PISs are likely to set the methodology, the variable as a proxy, and the scope of the port-related activities according to the particular research objective since they are short of the consensus on the definition and the category of the economic impact of ports. Nevertheless, the PISs are heavily dependent on the IO analysis as a whole but the econometric analysis has been widely applied since the 2000s. In conclusion, it can be clearly said that it is very important for a researcher to set up the research methodology appropriately according to the research purpose. The details of the research design are introduced in the chapter of research methodology.

Chapter 3 Port Systems in South Korea

3.1 Introduction

As mentioned in the literature review of port development models, the way that researchers look at port development has changed over time; the spatial relationship with the city, the functional connectivity in the transport network, the strategic behaviours of various stakeholders in a port community, etc.

This research trend is shown similarly in the research about what makes differences among ports in port development trajectories and port governance structure (Pallis et al., 2011, Notteboom et al., 2013a). According to Notteboom et al. (2013a), these research can be grouped into three approaches. The first approach is to focus on the long-term evolution of port systems (Bird, 1973), including the changing spatial relationship with the city (Hoyle, 1989, Norcliffe et al., 1996). The second approach is to analyse the governance systems of ports (Brooks and Cullinane, 2006a) in the line that ports are regarded as agglomerations of port- and logistics- related industries (De Langen, 2004). The third approach is to focus on the port community which various actors consist in based on a particular territory (Hall, 2003) and the relational structure in the port community which a variety of actors and stakeholders are influencing and/or influenced (Jacobs, 2007). In this sight, according to Ng and Pallis (2010), the relation and strategic behaviour of actors and stakeholders in the Port of Busan have partly influenced its development trajectory differently from the ports such as Rotterdam and Piraeus. These results imply that it is necessary for a better understanding of the port systems to consider the features in the surroundings, which influence the port-related activities, such as the changes in geopolitical systems and socioeconomic development policies as well as the changes in the port governance.

In this chapter, this study overviews general information with regard to the port systems in South Korea including the status of ports in transportation, the ports in general and four major ports. In order to do so, this chapter makes steps as follows. On one hand, the status of ports is overviewed as a sector of transportation in the sight of input and output. It starts from the brief understanding about the characteristics of the geo-economic-political system at the national level. On another hand, an overview with regard to the port systems follows in three sub-sections: ports classification, port development, and port governance. Firstly, in the sub-section of the port classification, how the ports are managed is mainly discussed. Secondly, a brief history of port development is implemented mainly focused on the priority of the port development policy. Lastly, in the sight of the port governance, this study supplies the characteristics of the relations between the government and the actors and/or the stakeholders in general. On the other hand, the commonality and the difference among the four major ports will be overviewed.

3.2 Port in Transportation

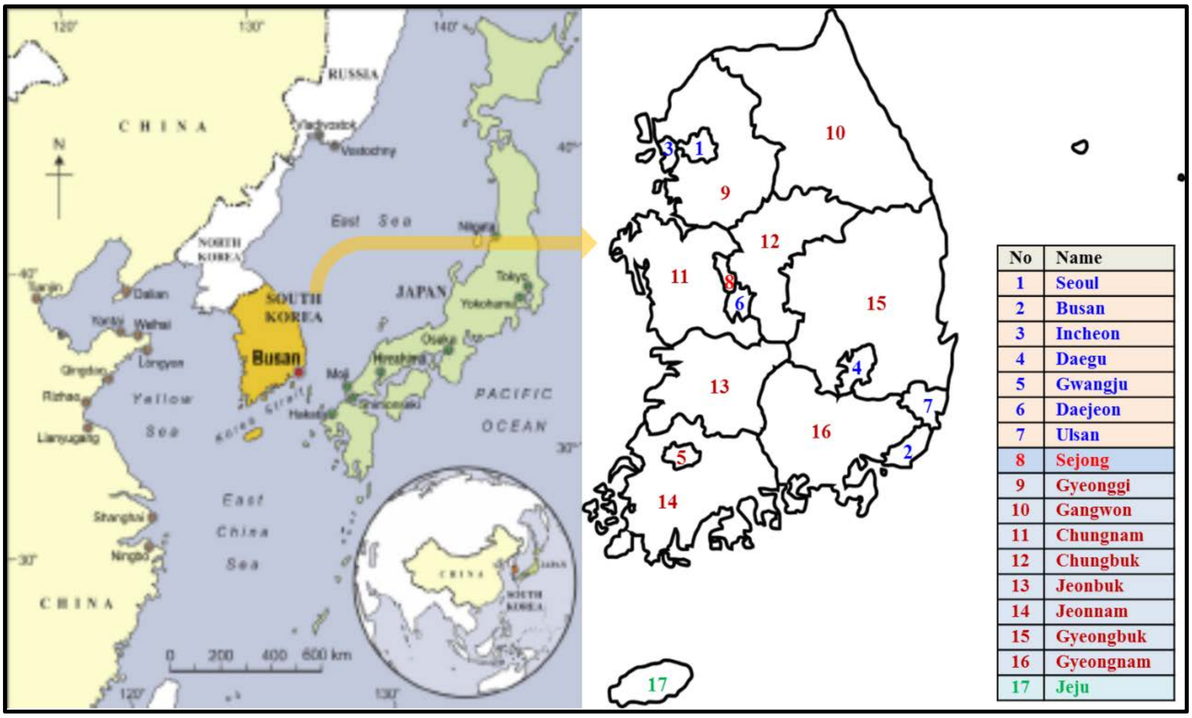
As mentioned by Lee and Lam (2017), 'a port is a kind of organic system in a national socio-economic-political system as well as the globalised economic system.' In this perspective, it can be said that a port and port systems in a country have been evolving itself and themselves through reflecting the changes and/or the trend in the structural system within the socio-economic-political system of a nation. For this reason, the comprehensive approach to the port system in a specific country needs to start from a general understanding of the structural characteristics of the whole system of the country concerned.

In this context, this study briefly overviews the geopolitical characteristics of Korea and examines the status and the role of port systems in the Korean economy through a general understanding of the transportation sector.

3.2.1 Geopolitical conditions

The understanding of Korea's geopolitical situation needs to start with the geographical features in which Korea is located. Korea is located on the Korean peninsula on the eastern end of the Eurasian continent, which is in touch with China and Russia, as shown in Figure 3-1.

Figure 3-1 Map of South Korea and regional jurisdictions



Note: No. 1 (Seoul) to 7 (Ulsan) are a Metropolitan City, No. 8 (Sejong) is a Self-governing City, No. 9 (Gyeonggi) to No. 16 (Gyeongnam) are a Province, and No. 7 is a Self-governing Province.

Source: redesigned by the author based on the left from Seo et al. (2015, p. 27) and the right from the website (http://kangzip.tistory.com/m/446).

In addition, Korea is surrounded by sea on the three sides and has a maritime boundary with Japan and China. Based on these geographical conditions, Korea has been in the unique condition that the geopolitical characteristics; especially, the relationship with North Korea and the relational changes with and/or among nearby powers, have quite fast and widely influenced the domestic systems of a country and the economic development trajectories.

First of all, in the geopolitical sight, South Korea is bordering North Korea which is located on the northern half of the Korean Peninsula across the Military Demarcation Line (MDL). Both Koreas have maintained an armistice for more than sixty years since the 1953 armistice agreement on the Korean War. In addition, they have repeatedly been in the relationship not only that they exchange and co-operate each other but also that they conflict without any communication. By this reason, South Korea has the embodied system just like an island country as it is disconnected to the Eurasian continent by land transport (Song and Lee, 2006).

Secondly, in the sight of the domestic political systems, South Korea had been led by a military dictator and by the presidents who have the background as a military over 30 years by the early 1990s. As a result, Korea had maintained such a centralized political system[28] that the President had exercised the high level of authority until the early 1990s. However, this political system has been changed extremely drastically since the mid-1990s due to democratic movements in the 1980s and the reintroduction of the local autonomy system since 1991 (SNU, 1994).[29] As a result, the Korean government have faced the increasing pressures for decentralization of authority and responsibility centred on the central government as the elections for the governor of the regional governments and the members of a regional assembly have been taken place over time (Lee and Lam, 2017).

Lastly, in the economic perspective, through experiencing 35 years of the Japanese colonial rule and 3 years of the Korean War, the Korean economy had plummeted to the extremely poor country whose Gross National Product (GNP) per capita was 79 US$ in 1960.[30] Under the conditions mentioned above, the Korean government had led the unprecedented economic growth by establishing and implementing seven phases of ‘five-year plan for economic development’ (MOF, 2016b).[31] In this process, the government had focused on export-oriented economic growth strategies while

[28] For example, the chief public officials of metropolitan cities and provinces were appointed by the President, based on the recognition that local governments are also part of the central government.
[29] In Korea, the Local Autonomy Law was enacted in 1949 and the local autonomy system was established. As a result, the local council was established and operated in April 1952. However, the Local Autonomy Law was suspended in September 1961 due to the enactment of the Temporary Measures Act on Local Autonomy. In 1988, the Local Autonomy Law was revived by a special revision of the Local Autonomy Law. As a result, the provincial council was formed as local election in 1991. In 1995, the head of the local government was elected. Since then, local elections have been held in 1998, 2002, 2006 and 2010.
[30] Source: the Bank of Korea, Economic Statistics System (ECOS).
[31] The first plan was applied from 1962 to 1966 and the seventh plan was applied from 1992 to 1996.

strategically allocating limited resources under the principle of selection and concentration (KPHA, 2011).[32] This economic growth strategy continued even after the IMF bailout[33] application in 1997. At the moment, the export-oriented economic growth strategy is still regarded as an important feature of the Korean economy (Song and Lee, 2017). As a result, the Korean economy maintains the structural characteristic that the share of international trade relative to GDP is very high[34] compared to the countries in OECD.

Based on the understandings of the geographical, political, and economic characteristics of the national system, this study continues to overview the status of the port in transportation as an industrial area in the following sub-section.

3.2.2 Status in transportation

It can be done by applying various indicators to see what position the port occupies in transportation. This study looks at the status of ports in transportation from the perspective of both input and output. As an input indicator, the amount of annual government budget for infrastructures and the capability of each infrastructure are overviewed. On the other hand, as an output indicator, the demand share of each transport mode is examined.

3.2.2.1 Investment for transport infrastructures

The Korean government manages major transportation facilities by the categories such as road, railway (including urban rail), airport, seaport, and others. Table 3-1 shows the amount of government budget for each sector. According to the Ministry of Strategy and Finance, the Korean government is investing around 20 trillion KRW[35] a year in transportation facilities in 2015 (MOF, 2016a). This is a 33% increase compared to 2006 and is equivalent to about 5.3% of the total government budget in 2015. Looking at each sector, road, railway, and others have increased in size over the last decade, while airport and seaport have declined in the government budgets. Especially, over 90% of the total budget is allocated to the three areas of road, railway and other facilities.

[32] In particular, due to the lack of underground resources, the Korean economy has focused on intermediary processing trade, which imports raw materials and intermediate goods and exports finished products and finished goods.

[33] The Korean government received $ 19.5 billion from the IMF, $ 7 billion from the World Bank (IBRD) and $ 3.7 billion from the Asian Development Bank (ADB) after signing a total of $ 55 billion in bailout agreements. However, the government began early repayment of the $ 13.5 billion of the supplemental reserve facility (SRF), which is short-term high-interest borrowings borrowed from the IMF, in September 1999. In addition, the government repaid all the bailouts he received from the IMF including the $ 6 billion of stand-by loan (SBL) on 23, August, 2001 (Doopedia).

[34] According to the World Bank, the share of international trade relative to GDP of Korea is 83.7% in 2015 compared to 56.4% of the average for OECD countries.

[35] Applying the currency (1 GBP = 1,447 KRW on 09 January 2018), 20 trillion KRW values 13.82 billion GBP.

Table 3-1 The investment of transport infrastructure from the Korean government budget

(Unit: ten million KRW, %)

	2006 (A)		2010		2015 (B)		A/B
Total	152,862	100.00%	175,219	100.00%	202,945	100.00%	32.76%
Road	73,567	48.13%	80,038	45.68%	90,845	44.76%	23.49%
Rail/Urban rail	45894	30.02%	53,512	30.54%	74,051	36.49%	61.35%
Airport	3,918	2.56%	666	0.38%	1,360	0.67%	-65.29%
Seaport	19,402	12.69%	18,617	10.62%	16,643	8.20%	-14.22%
Others	10,081	6.59%	22,386	12.78%	20,046	9.88%	98.85%

(Source: 'National Mid-term Financial Plan' cited in MOF (2016a).

Table 3-2 Changes over time of transport infrastructure capacity

Classification		2001 (A)	2005	2010	2015 (B)	Growth rate (B/A)
Road	Total length (km)	91,396	102,293	105,565	107,527	17.65%
Railway	Total length (km)	3,125	3,392	4,073	4,420	41.44%
Airport	Number of flight (1,000 times/year)	449	442			-100.00%
Seaport	National cargo handling capacity (mil. tonnes/year)	470	598	929	1,141	142.77%
	Container handling capacity (tho. TEU/year)	7,118	10,473	21,268	27,869	291.53%

Note: 1) 342km (5 routes) of National Highway in Jeju province was changed to provincial road according to Jeju Special Self-government Province Act as Jeju special self-government province was established in Jul 2006. 2) The data are from 2000. 3) The data are from 2006.
Source: compiled by the author from Korean Transportation Database and MOF (2016a).

As a result of investing the government budget continuously, it is clear that there is a steady increase of the stock in all fields, although there is somewhat a difference in the growth rate among sectors[36]. As shown in Table 3-2, since 2001, the capacity of the seaport facility has been growing at the fastest rate, which is 142% in 2015 relative to 2001. And then, the railway sector is showing the second fastest growth, which is a 40% increase in the total length of railroads in 2015. By contrast, road totals 107,565 km in the length in 2015 and has increased about 18% compared to 2001.

3.2.2.2 Transportation share structure

From the sight of output, the transportation share can be compared by applying three criteria; namely, passenger and freight, domestic and international, the measurement units, as shown in Table 3-3.

[36] There may be a significant difference between the growth rate of government budget and the growth rate of facility stock due to that it takes a considerable amount of time to construct a transportation facility and the construction periods are quite different among infrastructure types.

Table 3-3 Passenger and freight transportation share among transport modes in Korea

< Passenger Transportation > (Unit: thousand passengers/year, ratio %) (Unit: million passenger*kms/year, ratio %)

	Year	1990	2000	2010	2015	Ratio	1990	2000	2010	2015	Ratio
Domestic Passenger	Total	14,487,692	13,515,283	13,014,961	31,029,472	100.00%	135,335	132,841	146,715	464,853	100.00%
	Rail	644,814	814,472	1,060,941	1,269,417	4.09%	29,864	28,528	33,012	40,343	8.68%
	Urban rail	1,101,677	2,235,221	2,273,087	2,522,900	8.13%	11,229	21,030	25,369	28,028	6.03%
	Road	12,721,877	10,410,577	9,646,404	27,193,794	87.64%	89,712	74,572	79,440	385,018	82.83%
	Shipping	8,260	9,702	14,312	15,381	0.05%	520	672	883	757	0.16%
	Aviation	11,064	22,515	20,216	27,980	0.09%	4,011	8,039	8,011	10,707	2.30%
International Passenger	Total	9,863	20,451	42,822	64,051	100.00%	36,490	76,314	128,865	187,737	100.00%
	Shipping	236	999	2,761	2,617	4.09%	84	398	1,104		0.86%
	Aviation	9,626	19,452	40,061	61,434	95.91%	36,405	75,916	127,760	187,737	99.14%

< Freight Transportation > (Unit: thousand tonnes/year, ratio %) (Unit: million tonne*kms/year, ratio %)

		1990	2000	2010	2015	Ratio	1990	2000	2010	2015	Ratio
Domestic Freight	Total	337,145	676,315	778,031	1,927,283	100.00%	44,187	60,680	141,808	173,815	100.00%
	Rail	57,922	45,240	39,217	37,094	1.92%	13,663	10,803	9,997	9,479	5.45%
	Road	215,125	496,174	619,530	1,761,291	91.39%	9,325	11,412	104,476	132,382	76.16%
	Shipping	63,915	134,467	119,022	128,611	6.67%	21,127	38,298	27,220	31,841	18.32%
	Aviation	183	434	262	288	0.01%	72	167	115	112	0.06%
International Freight	Total	220,558	571,549	969,520	1,220,300	100.00%	1,838,205	4,375,042			100.00%
	Shipping	219,781	569,599	966,193	1,216,782	99.71%	1,833,650	4,362,779			99.72%
	Aviation	777	1,949	3,327	3,519	0.29%	4,555	12,263			0.28%

Note: the data of tonne-kilometre with regard to international freight has not been generated since 2010. Ratio is calculated by the data in 2015.
Source: compiled by the author from Korean Transportation Database (KTDB) operated by Korean Transportation Institute (KOTI).

Passengers have a slightly different result by year, but the road for the domestic passengers and aviation in the international passengers have the overwhelmingly high share regardless of the measurement unit. Meanwhile, with regard to the distance, road and urban rail have the slightly lower share of the passengers a year than by the passenger*kms a year. This means that road passengers and urban rail passengers use the traffic modes by shorter distance compared to rail, shipping and aviation. In international passengers, aviation takes charge of the share over 96% both by passengers a year and by passenger*kms a year.

On the other hand, in the case of freight, there is a large difference in the transportation share depending on both freight types and measurement units. Firstly, in the case of domestic freight, the share of road measured by tonnes a year accounts for about 92% but falls to about 76% when measured by tonne*kms a year. On the other hand, the share of shipping and the one of rail account for about 7% and 2% respectively by the tonnes a year, but the shares of them by tonne*kms a year increase to 18.32% and 5.45% respectively. It can be interpreted that the freight transported by shipping and rail is relatively longer than the one by road. Lastly, in the case of international freight, 99.7% or more of the total freight relies on shipping regardless of the measurement unit. This can be understood as the result is reflecting the fact that Korea is geopolitically similar to an island nation.

3.2.2.3 Role in international trade

The fact that most of the international freight is transported by shipping and handled at the port is very useful to understand the status of the port in the national economy. Furthermore, looking at the freight types handled at the port can supply the key information to understand the characteristics of the Korean economy in the sight of international trade. This is shown in Table 3-4, which shows the amount of freight types handled at the port in 2015. The table can be understood according to the transaction type and the freight type. That is divided into domestic freight and international freight which can be divided into import, export, and transhipment. This is categorized into 9 kinds of freight.

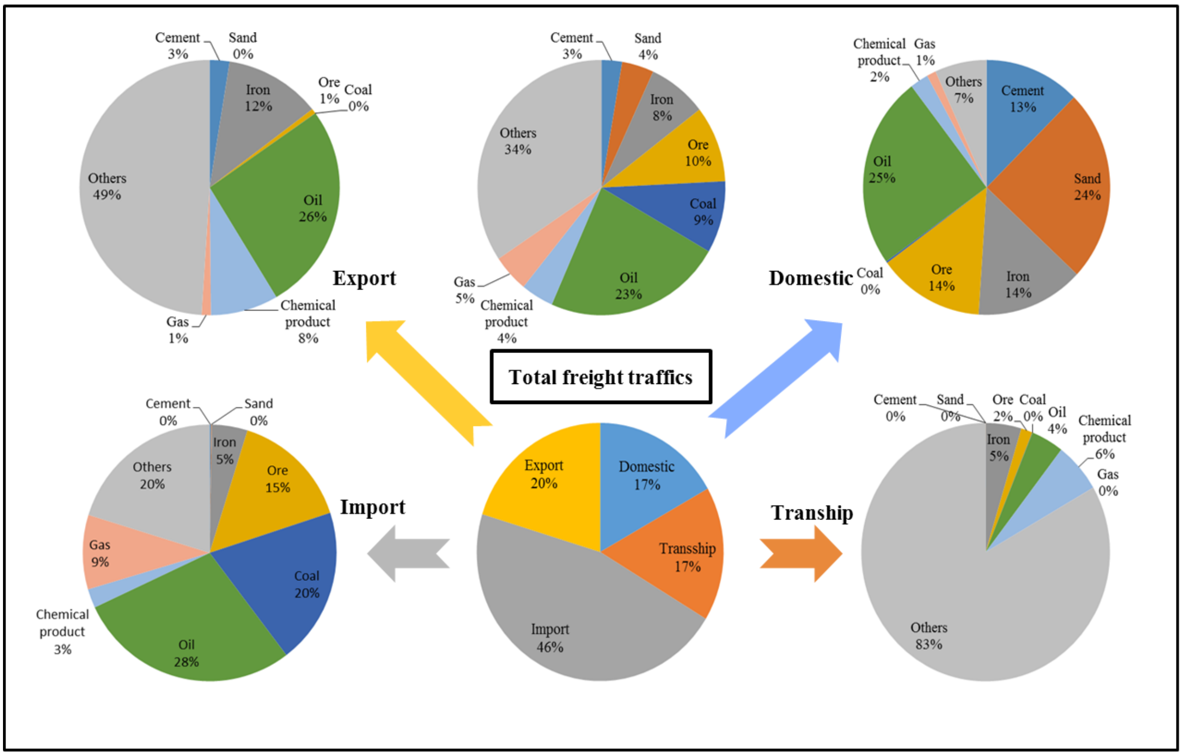
In terms of the transaction type, the amount of freight in 2015 is 1,463 million tonnes, of which international freight accounts for 83% and domestic freight accounts for about 17%. In particular, looking at international cargo in detail, imported freight accounts for 46% of total freight and 55% out of international freight. On the other hand, exported freight and transhipped freight account for 20% and 17% of total freight and 24% and 20% out of international freight, respectively.

With respect to the freight type, the share of nine freight types is shown in the pie chart at the bottom. The share of others, which includes container cargo, is highest at 34% out of total cargo and is followed by oil, ore and coal at 23%, 10% and 9%, respectively. With regard to import, oil accounts for 28%, followed by others and coal at 20%. In terms of export, others account for 49% and are followed by oil at 26%. In the case of transhipment, others account for 83%.

Table 3-4 National port cargo traffics and cargo type shares in 2015

(Unit: tonne (R/T))

Cargo type	Total	International	Import	Export	Tranship	Domestic
Sum	1,463,053,746	1,216,781,726	674,110,957	296,356,404	246,314,365	246,272,020
Cement	39,361,890	8,572,654	1,204,440	7,318,203	50,011	30,789,236
Sand	60,932,425	715,375	655,096	20,477	39,802	60,217,050
Iron	112,228,345	77,529,405	30,642,188	35,535,535	11,351,682	34,698,940
Ore	141,600,182	107,440,018	101,936,314	1,862,096	3,641,608	34,160,164
Coal	133,616,463	133,100,111	132,953,949	44,854	101,308	516,352
Oil	339,879,856	279,588,558	191,129,424	77,985,384	10,473,750	60,291,298
Chemical product	62,401,023	56,493,527	16,133,691	24,955,405	15,404,431	5,907,496
Gas	69,602,564	66,646,838	63,219,052	3,394,785	33,001	2,955,726
Others	503,430,998	486,695,240	136,236,803	145,239,665	205,218,772	16,735,758



The above results indicate that the Korean economy has the unique structure that natural resources and raw materials are imported and products are exported after processing. In addition, it can be said that a considerable amount of international cargoes are transhipped at the Korean ports due to geographical advantages.

3.3 Ports in General

3.3.1 Ports classification

The development and management of ports have been controlled by the Harbour Act[37] which was legislated in 1967 (MLTM, 2012a). The ports controlled by the Harbour Act have been developed and managed mainly by the central government for more than 40 years since 1967. The trends of the decentralization in the political circle were no exception to port-related policy. As a result, the Harbour Act[38] was revised in 2009 in order to meet steadily increasing demands for decentralization from regional governments and politicians who are influenced more directly from regional voters and improve port managerial efficiency (Lee, 2009).

By the criteria of a managing entity and the status of a port, all ports[39] controlled by the Harbour Act are categorised into four groups as shown in Table 3-5; 14 national ports and 17 municipal ports in trade ports, where the international cargo can be handled; 11 national ports and 18 municipal ports in coastal ports[40]. Due to Korea's geopolitical situation, the major ports are mainly located in its southern area of the Korean Peninsula as shown in Figure 3-2. Considering the research objectives, this study overviews port facilities and cargo traffics focused on 31 trade ports in next sub-sections.

Table 3-5 Port classifications in South Korea

National Trade Port (14 ports)	Municipal Trade Ports (17 ports)	National Coastal Ports (11ports)	Municipal Coastal Ports (18 ports)
Port of Incheon	Port of Seoul	Port of Yonggipo	Port of Daecheon
Port of Gyeong-In	Port of Taean	Port of Yeonpyeongdo	Port of Bi-in
Port of Pyeongtaek-Danjin	Port of Boryeong	Port of Sangwangdeungdo	Port of Songgong
Port of Daesan	Port of Jeju	Port of Daeheoksando	Port of Hongdo
Port of Gunsan	Port of Seogwipo	Port of Chuja	Port of Jindo
Port of Janghang	Port of Wando	Port of Hwasun	Port of Aewol
Port of Mokpo	Port of Hadong	Port of Gageohyangri	Port of Hanlim
Port of Gwangyang	Port of Samcheonpo	Port of Geomundo	Port of Sungsanpo
Port of Yeosu	Port of Tongyeong	Port of Gukdo	Port of Galdu
Port of Masan	Port Gohyeon	Port of Hupo	Port of Hwaheongpo
Port of Busan	Port of Jangseungpo	Port of Ulleung	Port of Sinma
Port of Ulsan	Port of Okpo		New Port of Nokdong
Port of Pohang	Port of Jinhae		Port of Narodo
Port of Donghae-Mukho	Port of Hosan		Port of Junghwa
	Port of Samcheok		Port of Busan South
	Port of Okgye		Port of Guryongpo
	Port of Sokcho		Port of Gangu
			Port of Jumunjin

Source: compiled by the author from MOF (2016b).

[37] The English name of the Act was changed to the 'Port Act' in 2008.
[38] The key point of the revision is that municipal governments' responsibilities are explicitly defined. In addition, some of trade ports, which were under central government's control, became administered by municipal bodies and some of coastal ports were opposite.
[39] Fishing ports are controlled by 'Fishing Villages and Fishery Harbors Act'
[40] Trade ports are open to international bodies so that international passengers can use and international cargo can be handled but coastal ports are not open to ships operated by foreigners.

Figure 3-2 Map of Ports of South Korea

Source: MLTM (2012a).

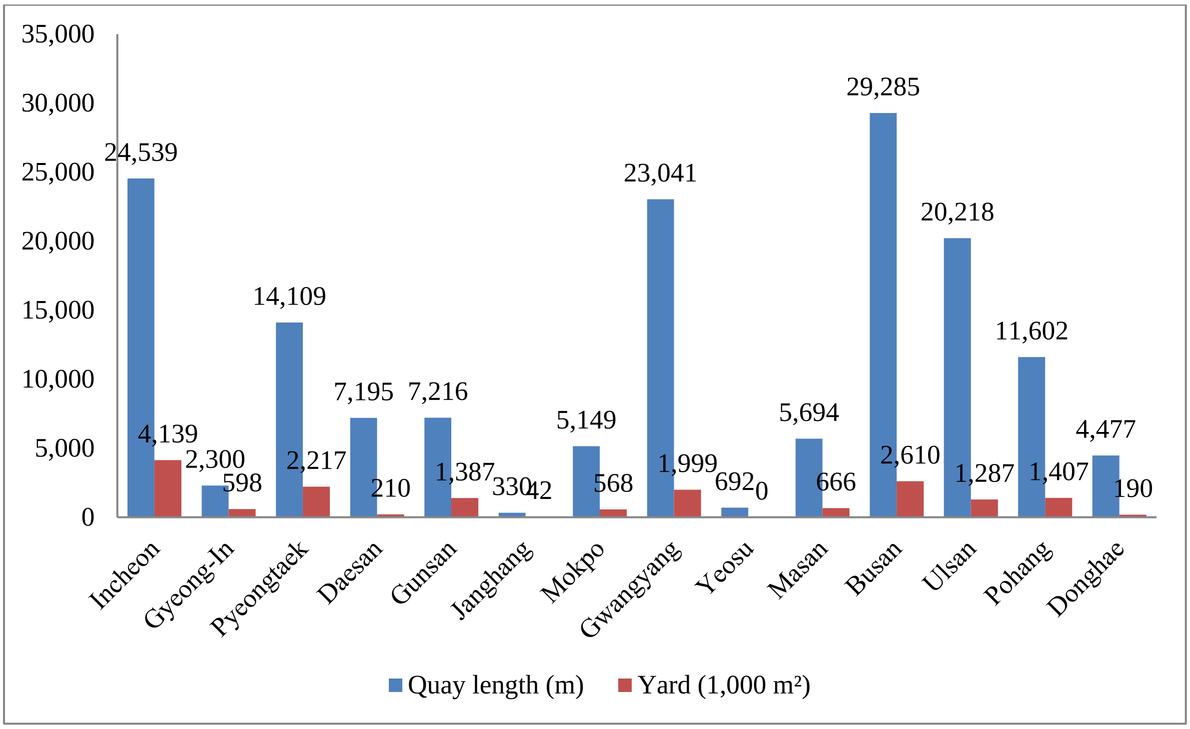
3.3.2 Port facilities

A port consists of various facilities such as water breaker, seaway, quay and/or wharf, apron, yard, various cargo handling machines, warehouse, and other supplementary facilities. However, in the sight of the cargo handling capacity of a port, the length of the quay and the area of the yard are the key components (MLTM, 2011a). For this reason, this research overviews the port facility in South Korea centred on the quay and the yard.

At the end of 2015, 14 national ports and 17 municipal ports are in operation as an open port. The whole length of the quay is 174,022m with 828 berths which are able to accommodate different sized ships as shown in Figure 3-3 and Figure 3-4. The 155,847m long quay of 731 berths is from 14 national ports and the 18,175m long quay of 97 berths is from 17 municipal ports. This means that a national port is in general much bigger than a municipal port except for a few ports such as the Port of Janghang and the Port of Yeosu in national ports and the Port of Jeju in municipal ports etc.

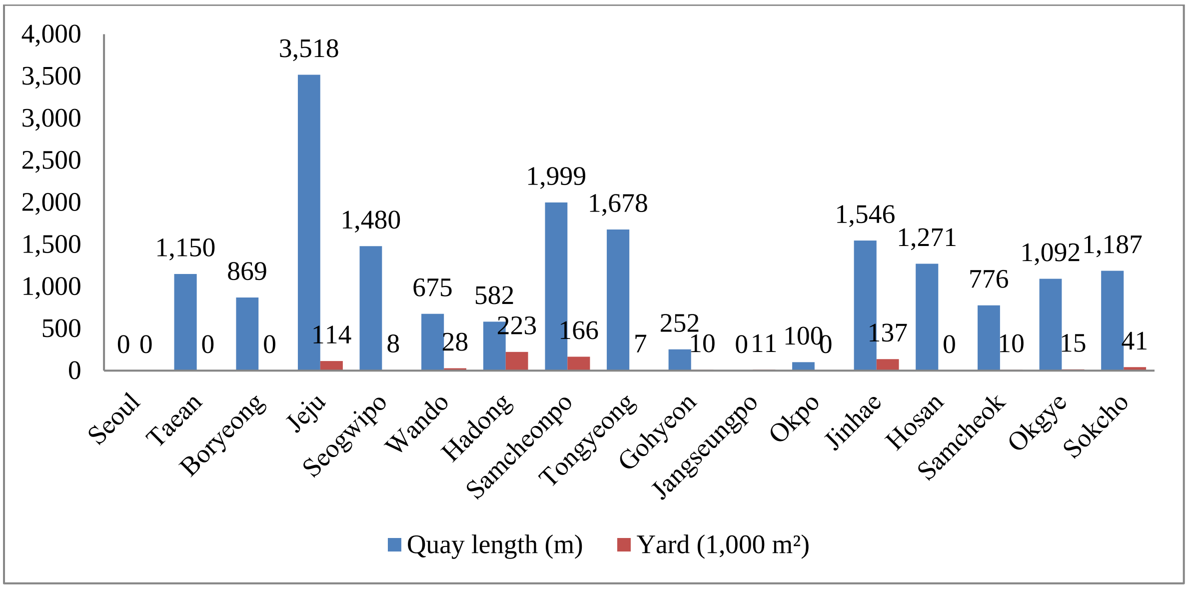
Looking over the facility of the national ports, the Port of Busan, the Port of Incheon, the Port of Gwangyang, and the Port of Ulan have the linear quay longer than 20,000m as major ports in Korea. As the second group, the Port of Pyeongtaek, the Port of Pohang, and the Port of Daesan, etc. have the quay which is around 10,000m. Meanwhile, in the sight of the area of the yard, the Port of Incheon, which has 4.13 million m^2 of the yard, is located at the first position and the Port of Busan, the Port of Pyeongtaek, and the Port of Gwangyang are following.

Figure 3-3 National ports by the length of the quay and the area of the yard



Source: compiled by the author from MOF (2016a) and MOF (2016b).

Figure 3-4 Municipal ports by the length of the quay and the area of the yard



Source: compiled by the author from MOF (2016a) and MOF (2016b).

With regard to municipal ports, the Port of Jeju has the longest quay, which is 3,518m, and the Port of Samcheonpo, the Port of Toyeong, and the Port of Jinhae are following. Meanwhile, in the area of the yard, the Port of Hadong has the biggest yard in municipal ports which is 223,000m^2 and the Port of Samcheonpo and the Port of Jinhae are following. In general, it is clear that municipal port has quite smaller yard than national ports.

3.3.3 Port traffics

As discussed in the previous section, Korea has some characteristics optimised to the geo-economical environments in the terms of economic development. As the island-like country which does not have abundant natural resources, Korea has adopted on the export expansion strategy to import raw materials and export processed and finished products (Song and Lee, 2017).

Table 3-6 Ports in cargo traffics in 2015 (unit: tonne, %)

		Total	National ports		Municipal ports
				Ratio	
Total		1,422,584,820	1,322,795,710	92.99	99,789,110
International cargo	Sum	1,216,781,726	1,150,269,175	94.53	66,512,551
	Import	674,110,957	610,035,978	90.49	64,074,979
	Export	296,356,404	293,992,601	99.20	2,363,803
	Tranship	246,314,365	246,240,596	99.97	73,769
Domestic cargo	Volume	205,803,094	172,526,535	83.83	33,276,559
	Proportion	14.47	13.04		33.35

Source: compiled by the author from SPICD (2017).

Figure 3-5 Cargo traffic of national ports by R/T

(Unit: thousand tonnes)

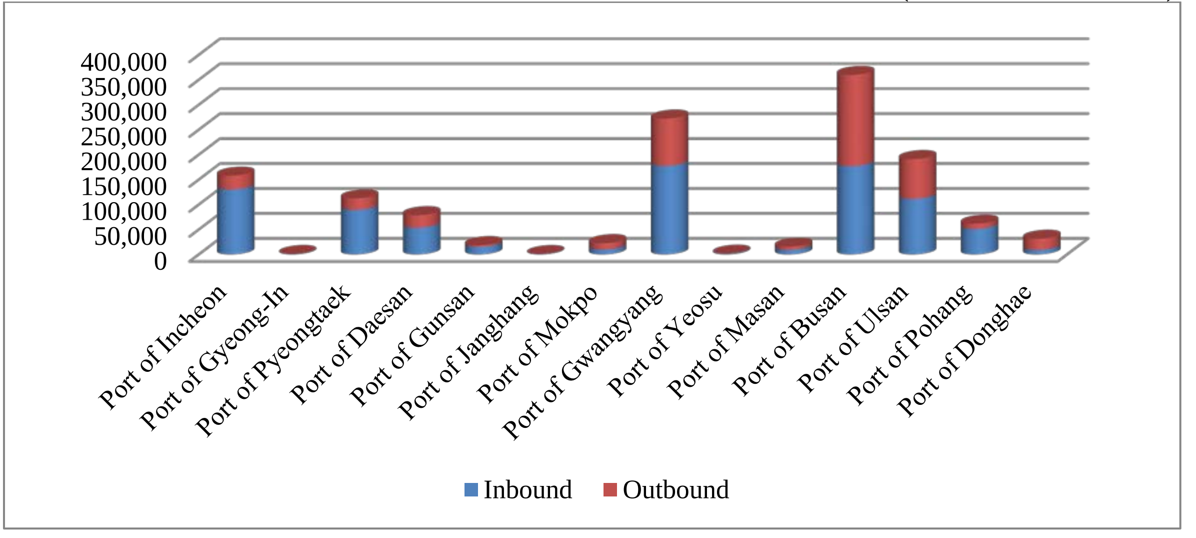


Figure 3-6 Cargo traffic of municipal ports by R/T

(Unit: thousand tonnes)

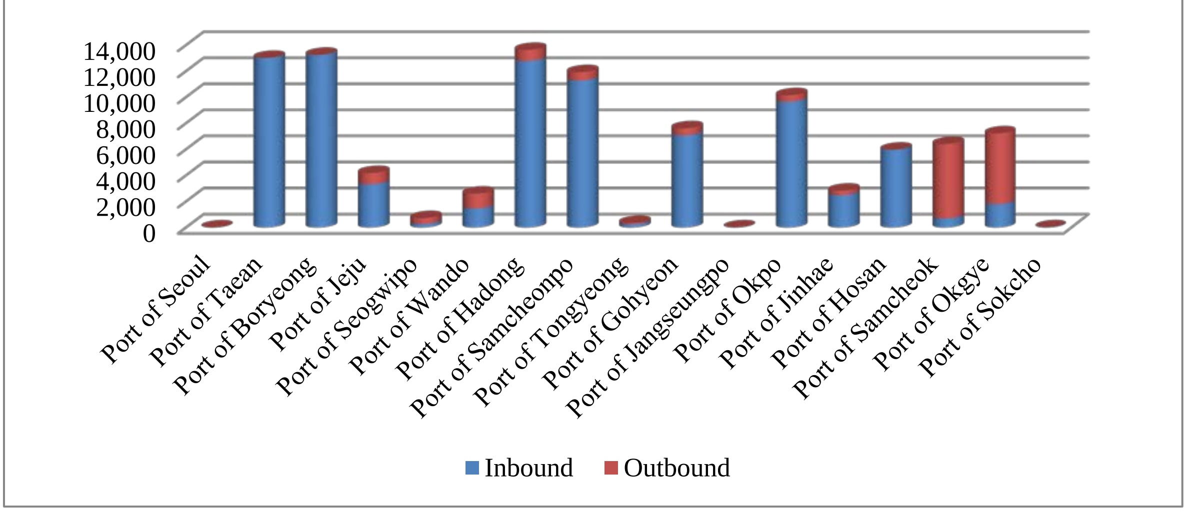
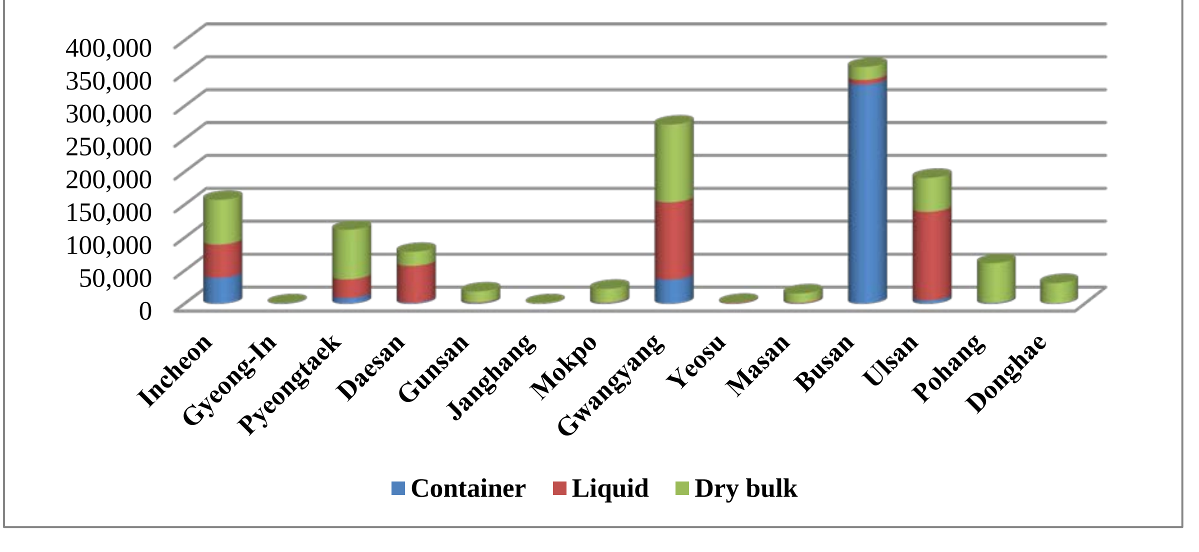


Figure 3-7 Cargo types of national ports by R/T

(Unit: thousand tonnes)



This economic development strategy might be read on the composition of the freights handled in the national ports as discussed in the previous sub-section. Following the previous discussion, this study overviews the freight composition focused on the port level.

At a national level, in 2015, the cargo volume handled in 31 international ports is 1,422 million Revenue Tonne (R/T).[41] as shown in Table 3-6. 14 national ports, whose amount is 1,322 million R/T, take charge of 92.99% of the national total volume and 17 municipal ports, whose amount is 99 million R/T, account for 7.01% of them. On one hand, the volume of international cargo accounts for 85.5% of the total volume; especially, the amount of imported cargo takes charge of almost half of the total cargo, and the amount of domestic cargo accounts for 15.5% of the total volume. On another hand, in the criteria of trade types, all trade types of cargo are mainly dealt with in national ports; especially, exported cargos are almost dealt with in national ports. However, imported cargos and domestic cargos occupy quite big proportions in municipal ports compared with exported cargos and transhipped cargos. On the other hand, the proportion of container cargo compared to the total national seaborne cargo is around 30% but the proportion of imported and exported container cargo, which does not include transhipped container traffics, is almost 16%.

At a port level, quite different characteristics are shown among both national ports and municipal ports, as shown in Figure 3-5, Figure 3-6 and Figure 3-7. First of all, the concentration of cargo volume is quite high among national port and municipal ports. As discussed in the subsection of port facilities, four major ports account for about 70% of the national total seaborne cargo.[42]; especially, the proportion of exported cargo volume handled in four major ports is almost 80% of the total exported cargo volume.[43]. Secondly, the portfolio of handled cargo is quite distinctive among ports. For example, the Port of Busan heavily concentrates on container cargo but several large ports have the different composition among container cargo, liquid cargo, and dry bulk cargo. In the case of municipal ports, they are mainly playing a role to support importing natural resources such as crude oil, natural gas, coal, limestone, and ironstone. Lastly, in terms of logistics chains with container centred, just several national ports are connected with the logistics networks on a global scale. In fact, three major ports such as the Port of Busan, the Port of Gwangyang, and the Port of Incheon, cover 95% of total container cargo.

[41] Revenue tonne is defined as the tonnage which the shipping company chooses out of the volume and the weight as a freight billing standard. Freight fares of shipping shall be indicated by the one which is calculated to be higher. As the criteria of the volume, cubic meter is calculated by multiplying the total volume by the respective unit price. On the other hand, as the price of the weight, metric tonne (M/T) is calculated by multiplying the total weight by the unit price. And then, M/T is applied when the price by the total freight weight is higher than the price by the total volume. (Ship Navigation Dictionary edited by Gong, G.Y)

[42] The proportion of total cargo volume handled in the Port of Busan, the Port of Gwangyang, the Port of Ulsan and the Port of Incheon is 25.3%, 19.1%, 13.4% and 11.1% in order.

[43] The proportion of exported cargo volume handled in the Port of Busan, the Port of Gwangyang, the Port of Ulsan and the Port of Incheon is 27.7%, 20.6%, 22.3% and 8.3% in order.

3.3.4 Port governance

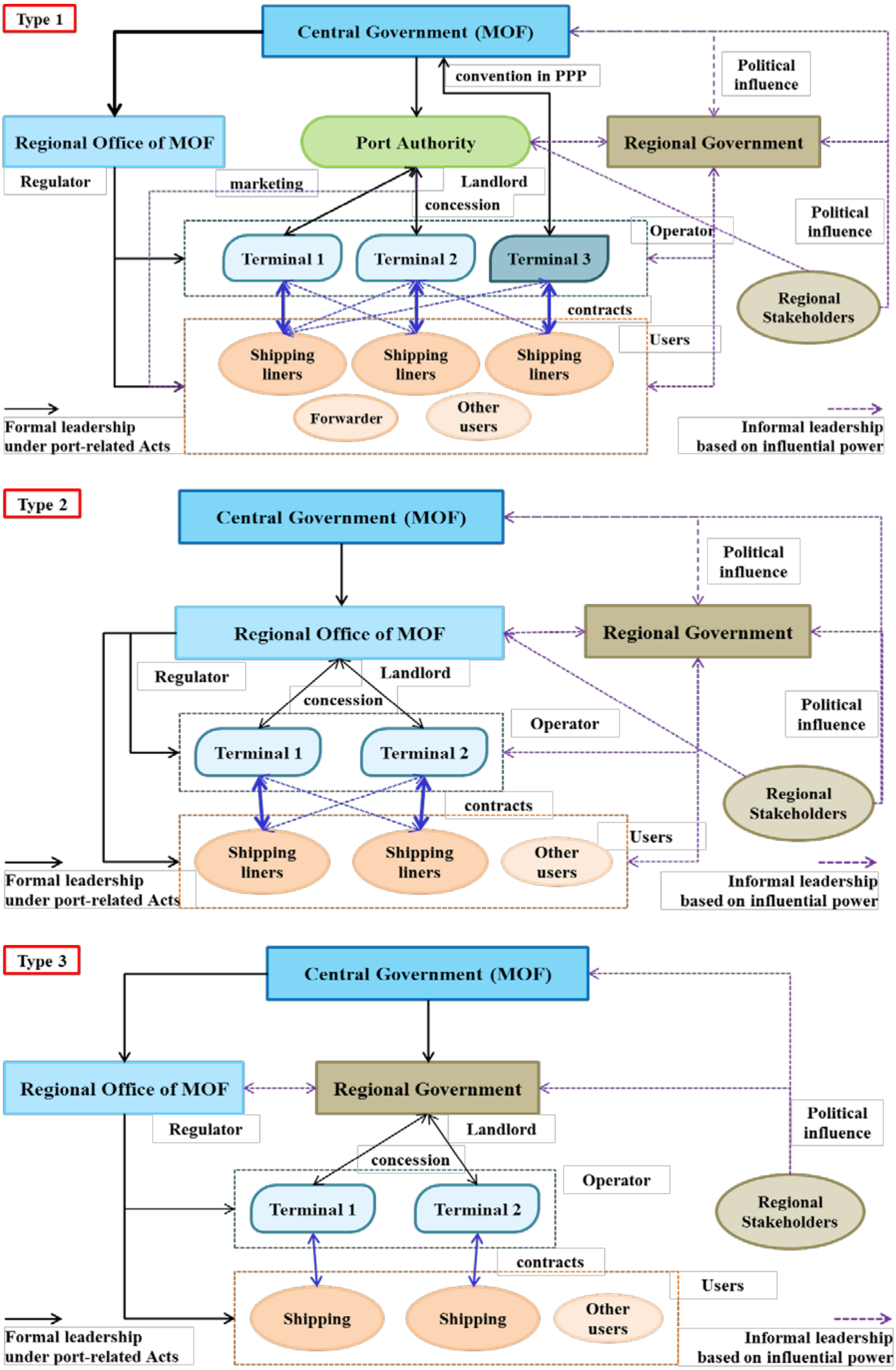
This study has overviewed the representative changes in the distribution of the authority and the responsibility as a key component of port governance in Appendix 1 (A.1.2 Port Governance). Especially, the discussion about the role of key actors and their inter-relationship must be the crucial point to clarify the type of Korean port governance. In this sub-section, this study clarifies the type of Korean port governance based on the discussion in Appendix 1. In order to do so, this study briefly introduces the devolution history in South Korea and suggests the typical features in the relationship between the stakeholders in the frame of the port governance.

Since the 1980s, port governance-related issues have been the top priority of port-related policies in many governments all over the world (Brooks and Pallis, 2012). South Korea has not been free from this global trend. As discussed in Appendix 1, the Korean government has focused on devolving the centralized authority and responsibility both at the terminal level and at the port level. At the terminal level, the devolution can be summarized the history of commercialization and corporatization by introducing non-governmental port construction[44] and the public-private partnership (PPP). On the other hand, the procedure at the port level can be expressed the history of decentralization that regional stakeholders such as the regional government and the port authority (PA)[45] have taken over the authority from the central government.

As of 2015, the relationship among key actors in the port community can be largely classified into three types, as shown in Figure 3-8. This figures are drawn by the author focusing on the relationship between the key stakeholders with the formal and informal leadership applied. All types are in common that the central government manage the plan and the policy with regard to port development and the regional office of MOF plays a role as a regulator with regard to seaman and safety-related matters. The first type[46] is the governance system that the PA plays a key role as a landlord which manages the port facilities including the wharf and the quay wall. The government exceptionally has the relationship with the container terminal operators who were tied by the convention in PPP. The regional governments are substantially playing the focal point that the political requests from regional stakeholders are concentrated on. The second type[47] is the governance system that regional offices

[44] If anybody who is not a government entity would like to construct and/or repair port facilities, he should get the permission from the governmental body who is responsible of building and managing port facilities. The private body has the right to use the port facility free of charge until port facility fee is equal to the amount invested.
[45] The PAs are a new legal entity in the sector which is so-called a public and private combined entity. This is benchmarked from the corporation model of Singapore that PSA Corporation was established as a new legal entity in order to succeed Port of Singapore Authority. The PAs in Korea are in full responsible for port operations and development both port district and its back-up areas.
[46] Four ports: the Port of Busan, the Port of Incheon, the Port of Ulsan, and the Port of Gwangyang.
[47] The regional offices of MOF play a role as a landlord in 10 national trade ports except for four major ports.

Figure 3-8 Three types of port governance system with respect to the trade ports



Source: drawn by the author based on MOF (2016a) and MOF (2016b).

Table 3-7 Governance model in the Korean ports

Port Governance Models	Port functions		
	Regulator	Landlord	Operator
PUBLIC	Public	Public	Public
PUBLIC/private	Public	Public	Private
PRIVATE/public	Public	Private	Private
PRIVATE	Private	Private	Private

Source: drawn by the author by applying the work of Baird (2000) cited in Brooks (2004).

of MOF, instead of the PAs in four major ports, are playing a role as a landlord and the role of regional governments is similar to the one in the first type. The last type[48] is the governance system that the regional government has the authority and the responsibility as a landlord and the focal point that regional stakeholders raise the political requests to.

On the other hand, this study evaluates the type of port governance in South Korea by applying the port governance model suggested by Baird (2000) cited in Brooks (2004). It is quite attractive to understand the type of Korean port governance model compared to other countries, even though there is the criticism that the model is over-simplified. The governance type of the Korean ports is broadly classified into the PUBLIC/private port model, as shown in Table 3-7. It is quite clear that both the type 2 and the type 3 in Figure 3-8 must be the PUBLIC/private model considering that the regional offices of the MOF and the regional governments are playing a role as a landlord. Meanwhile, it can be somewhat ambiguous if the type 1 is PUBLIC/private or PRIVATE/public. This may basically depend on the status of the PAs as discussed by Lee and Lam (2017) and Song and Lee (2017). Based on the same recognition that private sectors have played a dominant role in terminal operating, the former puts the stress on the substantial relationship between the central government and the PAs but the latter has more interests in the role of the PAs as the relationship with other stakeholders: especially, terminal operators and shipping liners. However, it seems that there is not much difference in understanding the legal status of the PAs as a public institution.[49] Finally, the governance type of even the PA centred ports must be clarified into the PUBLIC/private model.

[48] The regional governments (municipal government) are managing 17 municipal trade ports.
[49] Two papers stand on the same position with regard to the legal status of the PAs based on the facts that the PAs have been operated based on the PA Act as fully owned by the government and they are needed to get the permission from the government for the sale of major assets.

3.4 Four Major Ports

According to Lee and Lam (2017), it is necessary that the port systems at the national level are looked over in relation to various environmental factors as a part of the country's geopolitical and socio-economic system. As discussed by De Langen (2006), a port is a partial area of its city in which various activities of various stakeholders take place in space and in place. In addition, the port has been functioned in the global economic system (Hall, 2008) and evolved through interacting with the city centred on the interface (Charlier, 1992, Hoyle, 2000a). In other words, to better understand individual ports, it is necessary to understand them in relation to the various environmental factors surrounding the port (Wang and Slack, 2002), based on an overall understanding of the national systems by which the port is encompassed (Lee and Lam, 2017).

As discussed in the literature review, many researchers have interests in the various relationships between the port and the city: for example, the key factors of port development (Bird, 1963, Notteboom and Rodrigue, 2005), the features of the interface (Hayuth, 1982b, Hoyle, 1989), and a variety of approaches in port studies (Ducruet, 2011).[50] However, this paper focuses on understating the characteristics of each port in the sight of the port development trajectory and the status in the national port systems. To this end, this chapter consists of three sections. In the next section, this study provides a brief overview of the historical aspect based on the results of Appendix 3 Contextual Analysis.[51]

3.4.1 Brief History

3.4.1.1 Busan

The Port of Busan, which is located in Busan Metropolitan City (henceforth Busan) and the City of Changwon in Gyeongnam Province in the southeast of the Korean peninsula, is Korea's largest trade port. It has a 30km quay wall which can simultaneously accommodate 162 vessels as well as annually handling 354 million tonnes of various types of freight with a designed capacity of about 17 million

[50] For example, Ducruet (2011) categorizes the approaches into three groups by the key factor applied; economic impact and value-added of port activities, comparative analyses of urban and port dynamics, and statistical analysis of urban and port indicators.

[51] This appendix introduces the results of the development process for the four ports. Firstly, this study briefly reviews the port development trajectory after the opening of individual ports centred on how the port facilities have been expanded spatially. In this process, this study applies the topographical approach suggested by Bird (1963) and Notteboom and Rodrigue (2005). And then, this study examines how the interface has been formed and changed over time through using the approach applied by Lee and Ducruet (2006). Finally, this study evaluates the status of the ports by looking over the changes in key indicators and the role of the ports by examining the regional composition of cargos.

TEUs. It is the seventh largest container port in the world by the criteria of annual throughput in 2016 (SPIDC, 2017).

According to KPHA (2011), before the opening of the port in 1876, harbour functions were scattered in the river-side mooring grounds such as Dongrae and Choryang. However, port facilities moved and port function was integrated naturally in Busanpo, which was located in the coastal area, in order to accommodate the enlarged ships after the opening. Since 1912, various port facilities including the Pier 1, 2, 3, 4 and the Central Pier[52] had been developed in order to transport the war materials of Japanese armies during the Japanese colonial rule. Meanwhile, after the liberation of Korea in 1945, the Port of Busan had kept in the period of a slump due to the decline of the national economy during the 1950s and the early 1960s.

It had been a long time when the Port of Busan began to enter the explosively developing phase, thanks to the national economy which was gradually recovered since the mid-1960s. As a result, the central government introduced the IBRD loan two times in the 1970s in order to expand the port facilities. This developing trend had continued in the last decade with different financial resources invested by the government and private sectors. Today, the Port of Busan became the huge port with four sub-divisions consisted as shown in Figure A-1: North Port, Gamcheon Port, Dadaepo Port, and New Port. They are strategically developed and managed in accordance with the specific functions of each port.

3.4.1.2 Incheon

The Port of Incheon, which is located in the Incheon Metropolitan City (Incheon) in the central area of the Korean peninsula, is the largest trade port in the capital area (MLTM, 2012a). It has a 24.5km quay wall which can simultaneously accommodate 117 vessels as well as annually handling 157 million tonnes of various types of freight.

According to KPHA (2011), it has served both as the key point for protecting the capital area in the point of military defence and as the gateway to connect the capital area with foreign countries. Prior to the opening of the port in 1883, it played a role as a military base to protect the Capital and the Yellow Sea. In 1884, the government of the Joseon Dynasty established the department for shipping affairs in the Port of Incheon. In addition, in 1912, a regular route connecting the Port of Gunsan and the Port of Nampo was opened for the first time in Korea, centred on the Port of Incheon. In 1918,

[52] The Piers were reinforced in the 1970s and 1980s so that contributed to cope with the explosively increasing cargos for the last several decades. And then, they were gradually regenerated to coastal park and the business district since 2008 (the BPA website, 2017).

the 1st dock, which was quite rare in Asia, had been completed so that the Port of Incheon was able to overcome the huge difference of the tide and could be used for 24 hours.

However, after the Korean War in 1950, most of the port facilities had been destroyed so that the port almost lost the function as a port. Meanwhile, it was not until the 1960s, when the 2nd dock was built, that the port began to take a leap to the gateway of the capital area. Since the construction of the lock gate in 1974, the whole coastal area inside of the Inner Port could be used for the space of port facilities and port facilities had been developed by the 1990s. Entering the 2000s, as shown in Figure A-3, port facilities inside of Inner Port have spread out to South Port, North Port and New Port. Today, the Port of Incheon mainly consists of four sub-divisions: Inner Port, South Port, North Port, and New Port.

3.4.1.3 Ulsan

The Port of Ulsan is located in the Ulsan Metropolitan City (henceforth Ulsan) in the southeastern part of the Korean Peninsula. Especially, the Port of Ulsan, which is rooted on the estuary of the Taehwa River, has developed the trade port which handles the largest amount of liquid cargo handled in Korea. It has 20.2km quay wall, which can simultaneously accommodate 114 vessels, as well as port freight traffic of 190 million tonnes annually handled in 2015.

According to KPHA (2011), the Port of Ulsan was a small but important fishing port which had functioned as a safe place for fishing ships against severely bad weather just like Typhoon until the 1950s. However, the government had designated as an international trade port in 1963 in order to support handling cargo from and to Ulsan National Industrial Zone (Ulsan NIZ), which would be developed in the 1960s. In addition, the port has played a role as a gateway of Ulsan, which has led Korean industrialization since the 1970s, and the northeastern area of Gyeongnam[53], where several industrial complexes have been located.

On the other hand, the Port of Ulsan made a cornerstone for today's port by integrating Onsan Port in 1973 and Mipo Port in 1976, which had been constructed independently outside of the old Port of Ulsan (nowadays Main Port)[54]. As well, through turning the new century, the construction project of New Port was promoted in earnest in the coastal area in order to overcome the shortage and the inefficiency of existing facilities (MOMAF, 2001). Today, the port has four sub-divisions, as shown in Figure A-5: Main Port, Onsan Port, Mipo Port, and New Port.

[53] Ulsan was under the control of the regional government of Gyeongnam Province by 1996 and it has been an independent jurisdiction in 1997.
[54] The Port of Ulsan has been opened in the area of Main Port and the name changed to Main Port. The Port of Ulsan was changed to cover sub-divisions after two ports were integrated.

3.4.1.4 Gwangyang

The Port of Gwangyang is located in three small-scale cities in Jeonnam: the City of Yeosu (Yeosu), the City of Gwangyang (Gwangyang), and the City of Suncheon (Suncheon). The port is the only case that a port is surrounded by several cities at the lower level but not a metropolitan city. It has 23km quay wall, which can simultaneously accommodate 99 vessels, as well as port freight traffic of 272 million tonnes annually handled in 2015. Today, it is the second largest port with regard to the amount of cargo handled in Korea as following the Port of Busan (MOF, 2016b).

According to KPHA (2011), the Port of Gwangyang has a short but multi-stages history. The port originated from the Port of Yeocheon (formerly the Port of Samil)[55] which was opened in 1969 as such a large-scale industrial complex had constructed in the area of Yeocheon in the City of Yeosu in the 1960s. As the national petrochemical complex and the national oil reserve base were established, the Port of Yeocheon rapidly grew in a short period of time. In the early 1980s, the Pohang Steel Corporation (henceforth POSCO) built its second plant in the coastal area in Gwangyang. As a result, in 1986, the name of the port was changed to the Port of Gwangyang. In addition, as the waiting time of ships and cargos in the Port of Busan rapidly increased in the 1990s, large-scale container facilities implemented to be built in the port since the mid-1990s in order to deconcentrate the container cargos from the Port of Busan. The port has become as it is today, as container dedicated wharves have been opened from around 2000.

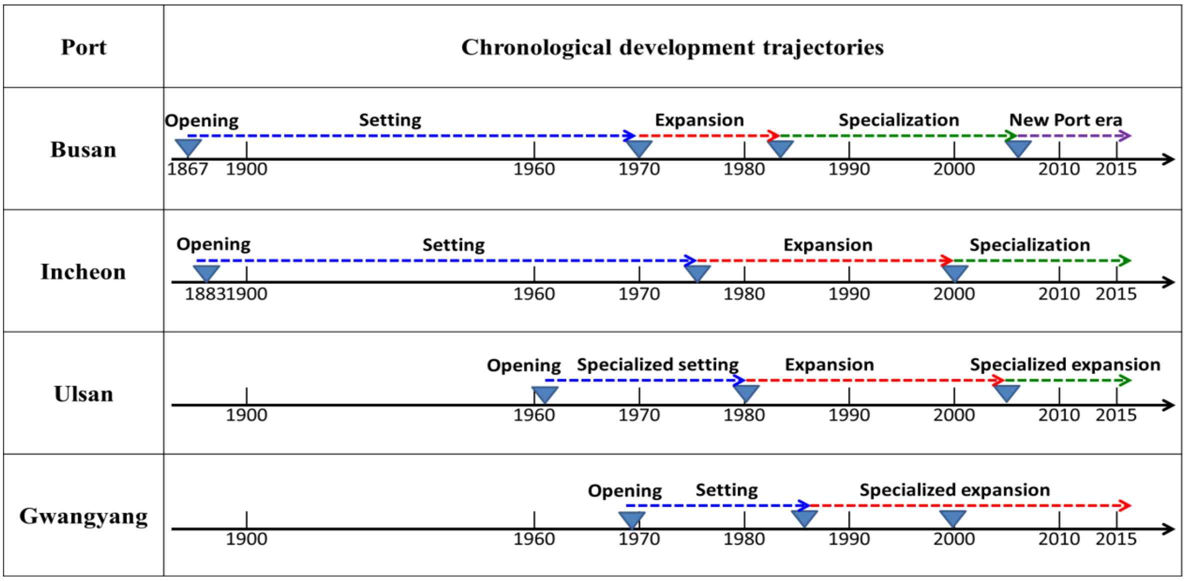
Today, the Port of Gwangyangt, as shown in Figure A-7, is strategically developed and managed with its detailed roles in four districts; Yeosu district where the Port of Yeocheon was located, Gwangyang district where POSCO is located, Gapo district where container-related facilities are located, and Yulchon district where future port development is planned.

3.4.2 Comparative Understanding

In the previous section, the brief history and the status of the four major ports were overviewed. In addition, in Appendix 2 Contextual Understanding fo the Four Major Ports, this research supplies the footprints that the four major ports have been making in both the different context and the different relationship. Based on these understandings of individual ports, this research suggests the characteristics of the four ports by applying the comparative analysis for a better understanding. In this section, the commonalities and the differences among the four ports are introduced in the four viewpoints such as the chronological review, the port development trajectory, the interaction with the city, and the status in port systems.

[55] The Port of Yeocheon is located in the mid area of Yeosu district; especially, like the small bay between No 1 and No 7 in Figure 7.

Figure 3-1 Chronological development processes of the four ports



Source: drawn by the author from KPHA (2011), KMPA (1991), MOMAF (2001), MLTM (2011a).

3.4.2.1 Chronological features

The four ports had originated as a fishing port and had enhanced their functions with different goals during hundreds of years before the opening of each port. However, focusing on the process of developing into the modern port, the four ports have several unique features. The four ports have played its specialized role as an international port since the opening. As shown in **Error! Reference source not found.**, the four ports have grown with the different phases while influenced by the geopolitical location and the economic development policies as discussed in the previous chapter.

On the one hand, the Port of Busan and the Port of Incheon have been developed since the opening of the late 19th century by experiencing three phases. The first phase of ‘Setting’ lasted more than 80 years; by the late 1960s in the case of Busan and by the mid-1970s in the case of Incheon. The second phase of ‘Expansion’ lasted for comparatively shorter periods; the early 1970s to the mid-1980s in Busan and the late 1970s to the late 1990s in Incheon. The third phase of ‘Specialization’ lasts for around two decades; the mid-1980s to the mis-2000s in Busan and the early 2000s to the present in Incheon. What is different between the two ports is that the Port of Busan has been in the additional phase which can’t be explained by the traditional morphological approaches since the late 2000s. Meanwhile, it can be said that the Port of Incheon has been in the third phase.

On the other hand, the Port of Ulsan and the Port of Gwangyang have been developed in earnest since the early 1960s and the late 1960s respectively in order to support coastal industrial complexes nearby the port in the industrialization era of Korea. The ports had settled down as an international port with the roles and the cargos optimized to nearby industrial complexes by the early 1980s. It is due to the features that the ports had been designed and developed in the line of the national economic development plan by the central government (KPHA, 2011). As a result, the two ports have shown quite different footprints at the point of the relationship between enlargement and specialization since the 1980s. The Port of Ulsan, where New Port has been developed in the line that the port facilities for similar cargo types are gathered at the similar location since the early 2000s, has been in the third phase of so-called ‘specialized expansion’. This is mainly because New Port has been developed with the aim to relocate the various types of cargo handled in Main Port or Onsan Port. On the contrary, the Port of Gwangyang has been in the second phase of expansion; however, the expansion is implemented on the strategic arrangement of the facilities by the cargo type. The port can be said to have been in the specialized expansion since the mid-1980s by developing Gwangyang district and Gapo district based on Yeocheon district. Furthermore, the two ports have experienced such a different phase from the traditional models and have stepped on the quite different route since the 2000s when the Port of Gwangyang began to open container dedicated wharves.

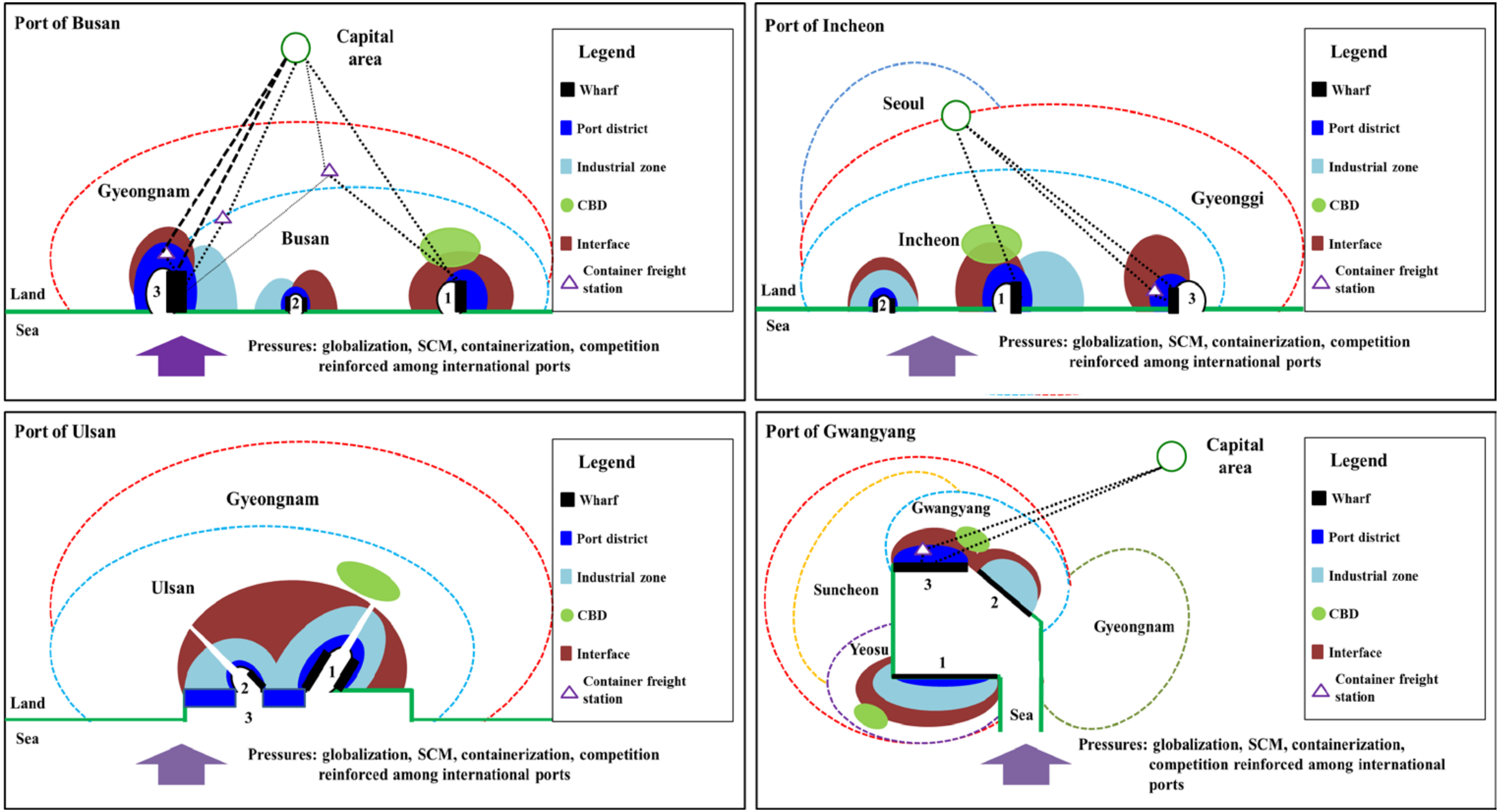
In conclusion, the Port of Busan and the Port of Incheon have followed the three phases of the traditional morphological models; however, the former is in the additional phase which can’t be explained in the frame of the existing model but the latter is in the third phase. Meanwhile, the Port of Ulsan and the Port of Gwangyang have not followed the typical process of the traditional models because the two ports have been developed under the specific objective to support nearby industrial complexes. These characteristics are shown in the composition of cargo types which is discussed in the later sub-section.

3.4.2.2 Topographical features

Both the topographical features and the spatial structures of the four ports by the simplified diagram are shown in Figure 3-9. The former is discussed in this sub-section, focused on where the ports are located and how the ports have expanded its own district, and the latter is done in the next sub-section as considering the spatial interaction between the port and the city.

Firstly, the Port of Busan and the Port of Incheon can be classified as the coastal port which is located inside of and/or around the small bay (NO 1) that the coastline enters toward inland and prevents the waves from the outer sea as shown in Figure 3-9, Figure A-1 and Figure A-3 in Appendix 2. When the port had settled down before the 1970s, the two ports had not needed a large-scale space in both sea area and land district. It is natural that it had been more important to securely develop and operate port facilities than to increase the scale or the capacity of the facilities. However, as the port grew fast and faced more strongly to meet the drastic changes in the shipping industries, it became impossible to secure additional space in the existing port area through the second phase of expansion: by the early 1980s in the Port of Busan and by the end of the 1990s in the Port of Incheon. As a result, the two ports expanded additional facilities, on the one hand, inside of the closest bay from the

Figure 3-9 Characteristics of the four ports in sight of the geographical and spatial structure



Source: drawn by the author with Lee and Ducruet (2006) applied from KPHA (2011), KMPA (1991), MOMAF (2001), MLTM (2011a).

existing one and on the other hand, while specializing the type of cargo according to the size of the bay. Meanwhile, the two ports have a difference in the sight of the scale of new port facilities. On one hand, in case of the Port of Busan, the New Port (No 3) needed such a huge-scale space so that it is located in the large bay more 35km far from the North Port (No 1). On the other hand, in case of the Port of Incheon, new port facilities are arranged in the different areas (No 2 and No 3) which are slightly small on a scale compared to the Inner Port (No 1).

Secondly, the Port of Ulsan has shown the features of a river port and/or an estuary port as shown in Figure 3-9 and Figure A-5. The Main Port (No 1), which is the birthplace of the Port of Ulsan, had been developed at the left-sided bank of Taehwa River and has expanded port facilities both along the riverside and on the right-sided bank of the river. In addition, the Onsan Port (No 2) has been grown as following the similar steps with the Main Port. As a result, the Port of Ulsan had followed the spatial features which were suggested by 'Anyport model' until the early 2000s. After then, as the port made a step toward the third phase based on New Port (No 3), the port began to show partially the characteristics of a coastal port. As a result, the port has main divisions with the boundaries touching each other differently from three other ports.

Lastly, the Port of Gwangyang has the unique characteristics in the topographic sight compared to the previous three ports. As shown in Figure A-7, the port is located inside of such a huge bay, which is called as the Gwangyang Bay, and began to settle down in the coastal area of Yeosu (No 1). As additional port facilities were necessary over time after the phase of the setting, the facilities began to be formed at the different coastal areas of the bay (No 2 and No 3). As a result, the Port of Gwangyang can have grown through adding additional functions in the separate sites, even though the port is located in the coastal area.

To summarize, it is clear that the development trajectories of the four ports are highly influenced by the topographic features and the four ports have significantly different shapes in the sight of both the spatial arrangement and the spatial structure.

3.4.2.3 Interaction with the city

The interaction between the port and the city is discussed in Appendix 2, focused on what relationship the port and the city have been in while both have grown over time. Based on the review, this research briefly summarizes what common features and differences of the four ports are. This review is implemented in the sight of chronological changes and spatial structures. In order to do so, this research follows the methodology suggested by Hoyle (1989), as considering the characteristic that the Hoyle's one is very simple but quite effective to show the changes of the interface over time

(Wiegmans and Louw, 2011).[56] The changes in the interactions are summarized as shown in Figure 3-10. At a glance, it can be understood that the interactions between the port and the city have been developed very differently.

First of all, the first three ports have the common feature that Busan, Incheon, and Ulsan already grew into a metropolitan city whether the growth of each city has been dependent on the growth of the port or not. The first two ports had directly contributed the city to grow a metropolitan city through attracting and agglomerating various port-related industries (Woo, 2009) before the port entered into the second stage of port development. However, the Port of Ulsan had indirectly done since the main role of the Port of Ulsan is supporting the industrial complexes through simplifying the procedure and saving the costs to import the raw materials and export the products nearby the manufacturing plants (Yoo, 2012). For example, a huge body of companies in the Ulsan National Industrial Zone has utilized port-related activities in their own facilities or the port-facilities connected to their plants.

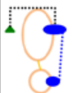
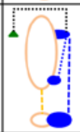
Secondly, the Port of Busan and the Port of Incheon are in common that they have settled down as a modern port during the longer period compared to the Port of Ulsan and the Port of Gwangyang.[57] As well, both of them have the commonality that port-related facilities, whether they were located in waterfronts and coastal areas or not, lead the city to expand the urbanized area through redeveloping the area where had been used for port-related activities (Woo, 2009). However, in the sight of the interaction over time, it is not difficult to find several differences between the two ports. On the one hand, in the case of Busan, the port has rapidly expanded both port facilities and the interface with the city since the 1970s. Especially during the 1980s and the early 1990s, port-related facilities were installed at the outskirts of the urbanized area which were comparatively short of accessibility (Yang and Lee, 1991). After then, these facilities were gradually redeveloped into the urbanized area; especially, housing complexes and business districts from the mid-1990s to the early 2000s.

As a result, they had contributed to the spreading out of the urbanized area to the outskirts. Especially, since the mid-2000s when the New Port was opened, the interface has expanded to the hinterland area nearby the New Port, while the one surrounding the North Port has partially been reduced due to the urbanizing project in some piers. On the other hand, in the case of Incheon, the port and the city had grown together and the interface had expanded to all directions surrounding the port district until the 1980s. However, as the city grew faster in the 1990s than the port did, the city became more interested in the port policy from the urban planning point of view. As a result, through passing the 2000s, the port facilities have been expanded as accommodating the urban planning of Incheon

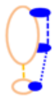
[56] There are a variety of methodologies for measuring the interactions between the port and the city.
[57] The Port of Busan and the Port of Incheon do not have a long history as a modern port as long as the ports in western countries as shown in Lee et al (2008).

Figure 3-10 Interactions of four ports with its own city over time

Port of Busan

Period	Stage	Symbol	Characteristics
The opening to the 1960s	Setting port/city		✓ Port contributed the setting and the growth of city as the spatial and functional community
The 1970s to the early 1980s	Expanding port/city		✓ Rapid commercial growth forces port to extend outward and city to expand outskirts
The mid-1980s to the early 1990s	Specializing port & expanding city		✓ Port facilities are specialized to set additional interface between port and city in the relation to existing facilities ✓ Port-related depots support port in outskirts of urban area
The mid-1990s to the early 2000s	Specializing port & overwhelming city		✓ Port facilities are developed in the line of specialization and port functions are connected with inland depots ✓ City expands through redeveloping the area used for port-related depots
The mid 2000s to the present	Setting New Port & invading interface to North Port		✓ Huge amount of port facilities are developed beyond the existing port districts by keeping the relationship with the existing facilities ✓ City expands its urbanized area nearby the interface between port and city

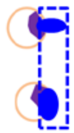
Port of Incheon

Period	Stage	Symbol	Characteristics
The opening to the mid-1970s	Setting port/city		✓ Port contributes the setting and the growth of city as the spatial and functional community
The late 1970s to the 1980s	Expanding port/city		✓ Rapid commercial growth forces port to extend outward and city to expand inland ✓ Port continues to contribute the growth of city
The 1990s	Expanding city/port		✓ Rapid growth of city continues toward inland thanks to other infrastructure not port ✓ City begins to influence the port-related policies in the sight of urban planning ✓ Port-related depots support port in outskirts of urban area
The early 2000s to the present	Specializing port & overwhelming city		✓ Port facilities are developed in the line of specialization to distribute the cargo types according to the features of nearby areas on urban planning ✓ City expands through redeveloping the area for port-related activities and extend the area nearby new ports

Port of Ulsan

Period	Stage	Symbol	Characteristics
The opening to the 1970s	Setting city/port		✓ Coastal industrial complexes needs to develop port without any interface between port and city
The 1980s to the mid-2000s	Expanding city/port		✓ Rapid industrial growth forces port to extend outward and city to expand inland ✓ Port doesn't have a direct spatial interface with urbanized area blocked by the huge industrial complexes ✓ City begins to face the problem such as the lack of space and heavy congestions
The late 2000s to the present	Specializing port & expanding city		✓ Port facilities are expanded in the line of specialization to relocate similar types of cargo as considering the features of nearby industrial complexes ✓ Industrial activities overflow outward outskirts and rural areas nearby city ✓ City begins to have interests in port-related policies in order to solve the local problems such as the lack of space and heavy congestions

Port of Gwangyang

Period	Stage	Symbol	Characteristics
The opening to the mid-1980s	Setting city/port		✓ Coastal industrial complexe needs to develop port without any interface between port and city
The late 1980s to the late 1990s	Expanding city/port		✓ Rapid industrial growth forces port to extend outward and city to expand inland ✓ Port doesn't have a direct spatial interface with existing urbanized area blocked by the huge industrial complex ✓ Another interaction between port and industrial complex forms in the similar shape
The early 2000s to the present	Specializing port & expanding city		✓ Port facilities are expanded in the line of specialization to relocate similar types of cargo ✓ Container dedicated facilities are developed and forces port to build interface with city ✓ City depends mainly on the growth of industrial complex and partially on the container related logistics ✓ City has lots of interests in the development of port as additional growth engine of regional economy

Note: ; urbanized area of a city, ; port area, ; industrial area, ; inland container depot

Source: compiled by the author from KPHA (2011), KMPA (1991), MOMAF (2001), MLTM (2011a).

(MLTM, 2011a). In this process, the whole interface has expanded, but some area nearby the Inner Port is supposed to retreat.

Lastly, focused on the Port of Ulsan and the Port of Gwangyang, there is a common point with regard to the similar spatial structure. In fact, both ports have so small interface with the city due to the existence of the coastal industrial complexes between the port and the city. Meanwhile, there have been huge differences since the 2000s. The interface with the city has been rapidly expanded in the Port of Gwangyang as the container dedicated facilities have been developed in. In addition, there is such a huge difference in the point whether the port leads to growing the city. In the case of Ulsan, the port has been expanding thanks to the explosive increase of the industrial activities, even though the port did not have a direct interface with the city. Nevertheless, the city became to have huge interests in the port policy as a means to solve some challenges such as the traffic congestion and space shortage in urban areas (MLTM, 2011a). On the other hand, in the case of Gwangyang, the port area is located in three different administrative districts which are a small or medium-sized city. As a result, the cities have the characteristic to depend heavily on the coastal industrial complexes and the port in terms of the economic growth and the spatial expansion. Particularly, since the container-dedicated facilities have been operated in the 2000s, the port can be evaluated to have a direct interaction with the city and contribute to the growth of the Gwangyang regional economy.

In conclusion, the comparison understanding clearly supposes that the interactions of the four ports with the cities have significantly different from each other. Nevertheless, it is clear that the four ports have the commonality to play a positive role or a spearhead of the spatial expansion of the urbanized area in their cities.

3.4.2.4 Status in the port systems

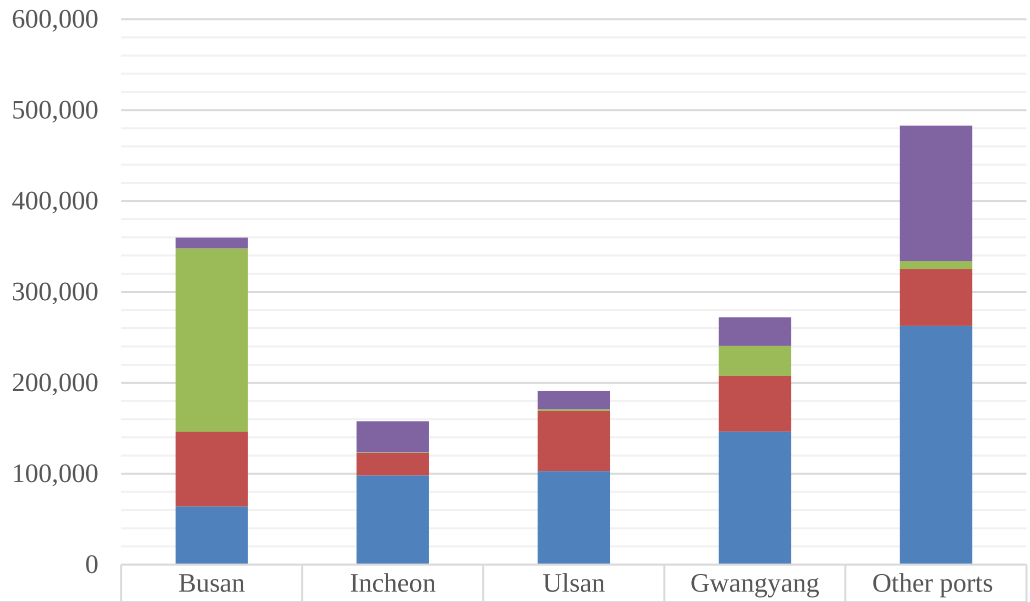
It is both at the level of a port and at the level of the port systems that the four ports have such significantly different characteristics from each other. It is because that understanding the status of individual ports in Korea's overall port system is also helpful in understanding the characteristics of individual ports. In this part, this research overviews the characteristics of individual ports in the port systems with four steps as follows. This starts from an understanding of the status of each port with the performance in 2015 in the sight of the total amount of port cargo traffic in the national port systems. Secondly, the study examines the composition by the cargo type in the four ports. Then the regional composition of the container cargos handled in each port is discussed. Lastly, the role and the status of individual ports in relation to the port systems at the national level are examined.

Firstly, the major four ports, which handled 980.1 million tonnes in 2015 as shown in Figure 3-11, account for about 70% out of the total volume of 1,423 million tonnes handled at the international trade ports all. The Port of Busan of 359.7 million tonnes accounts for 25.3% out of the total trade volume and is followed by the Port of Gwangyang (19.1%), the Port of Ulsan (13.4%) and the Port of Incheon (11.1%). On the other hand, looked at the composition of the cargo freight, the four ports have a quite different feature. In the port of Busan, the transhipment of 201 million tonnes occupies the greatest proportion out of the total volume, and the exported freight of 82 million tonnes and the imported of 64 million tonnes also account for a large proportion. On the contrary, the other three ports have the commonality that the imported freight occupies the greatest proportion which is more than 50%. In detail, the imported freight in the Port of Gwangyang and the Port of Ulsan is relatively higher due to a large amount of the imported raw materials, while the imported in the Port of Incheon have a higher proportion due to the imported products for the capital area.

Secondly, the four ports have a different composition of the freight types as shown in Figure 3-12, Figure 3-13 and Figure 3-14. Especially, the amount of 'others' which container freight is included in, is quite different by port. The proportion of 'others' in the Port of Busan with 297 million tonnes handled is quite high as 83%. The Port of Incheon with 57 million tonnes, the Port of Gwangyang with 46 million tonnes, and the Port of Ulsan with 24 million tonnes respectively record the proportion of 'others' of 36%, 17% and 13%. This feature is also seen in the proportion of 'others' as looking in the case of the port cargo traffic at the level of the exported freight in Figure 3-13 and the imported in Figure 3-14. Furthermore, focused on container freight traffic, it is much clearer that

Figure 3-11 Port cargo traffics of the four ports in 2015

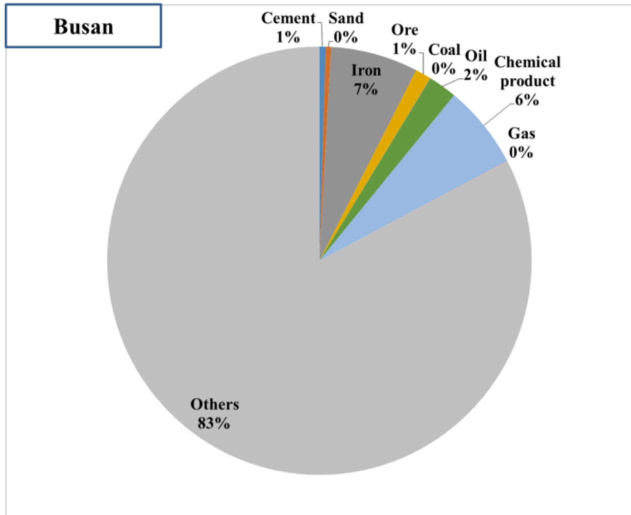
(Unit: thousand tonnes)



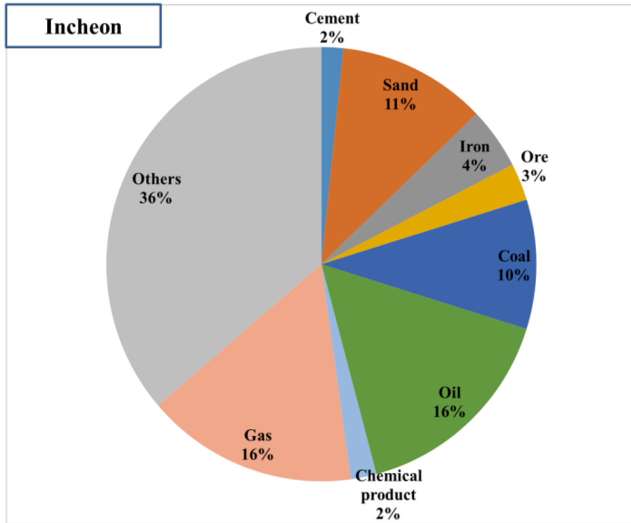
	Busan	Incheon	Ulsan	Gwangyang	Other ports
Domestic	11,963	34,099	20,099	31,077	149,034
Transhipment	201,558	700	1,856	33,574	8,656
Export	82,058	24,732	66,156	61,029	62,381
Import	64,098	98,123	102,758	146,326	262,807

Source: compiled by the author from SPIDC (2017).

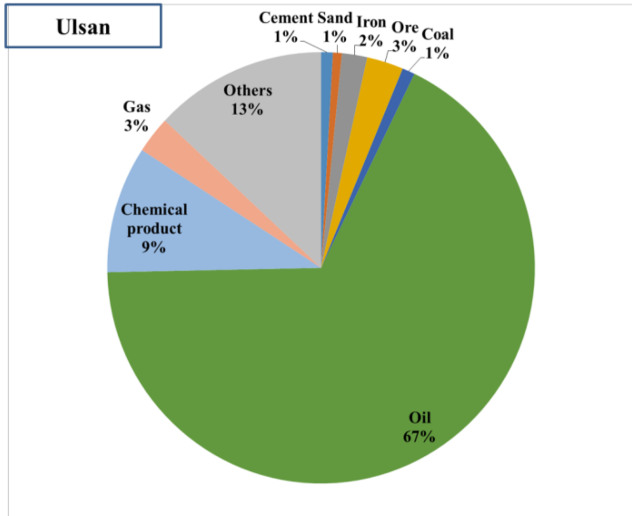
Figure 3-12 Compositions of the types of the total cargo traffic in four major ports in 2015



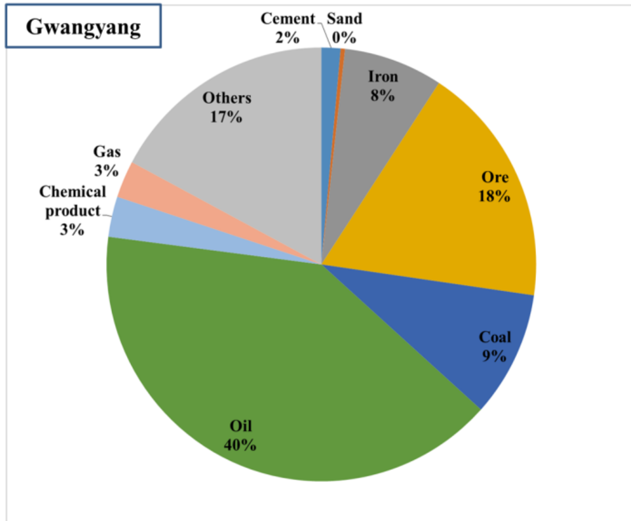
Cargo type	R/T (k tonnes)
Total	359,677
Cement	1,727
Sand	1,449
Iron	23,948
Ore	4,397
Coal	84
Oil	7,767
Chemical product	22,859
Gas	156
Others	297,289



Cargo type	R/T (k tonnes)
Total	157,624
Cement	2,587
Sand	17,640
Iron	7,246
Ore	4,366
Coal	15,169
Oil	25,310
Chemical product	3,026
Gas	25,083
Others	57,197



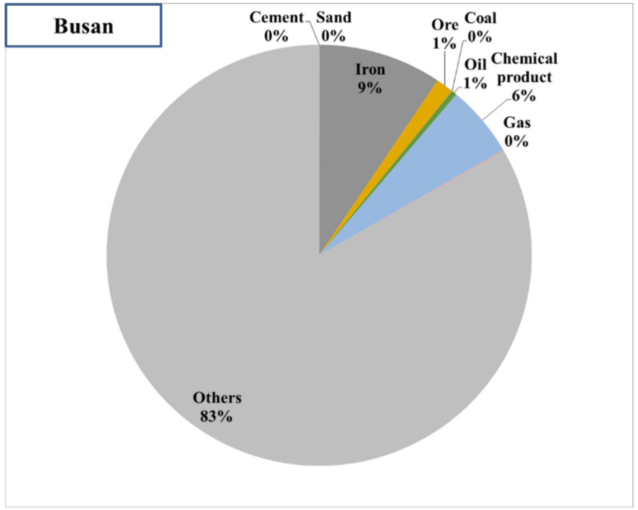
Cargo type	R/T (k tonnes)
Total	190,870
Cement	1,695
Sand	1,281
Iron	3,643
Ore	5,293
Coal	1,825
Oil	128,791
Chemical product	18,176
Gas	5,281
Others	24,885



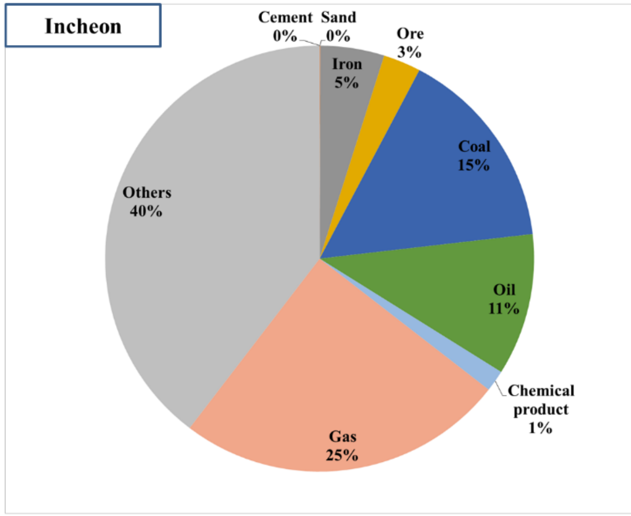
Cargo type	R/T (k tonnes)
Total	272,007
Cement	3,907
Sand	900
Iron	20,293
Ore	49,095
Coal	25,551
Oil	109,807
Chemical product	8,182
Gas	7,520
Others	46,751

Note: container freight and other products are classified as ‘Others’. Source: compiled by the author from SPIDC (2017).

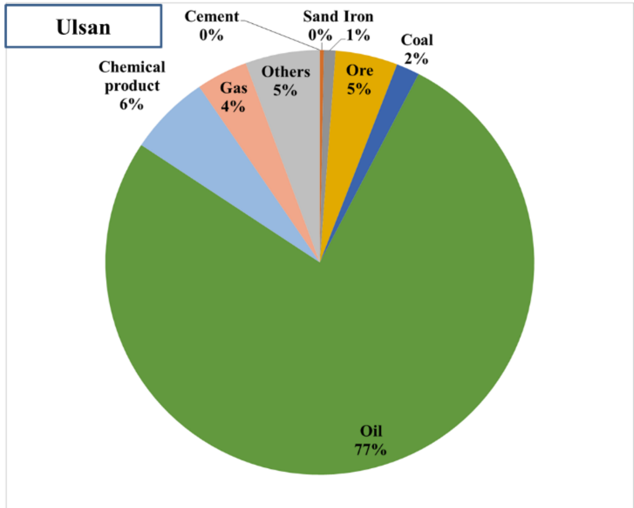
Figure 3-13 Compositions of the types of imported cargo traffic in four major ports in 2015



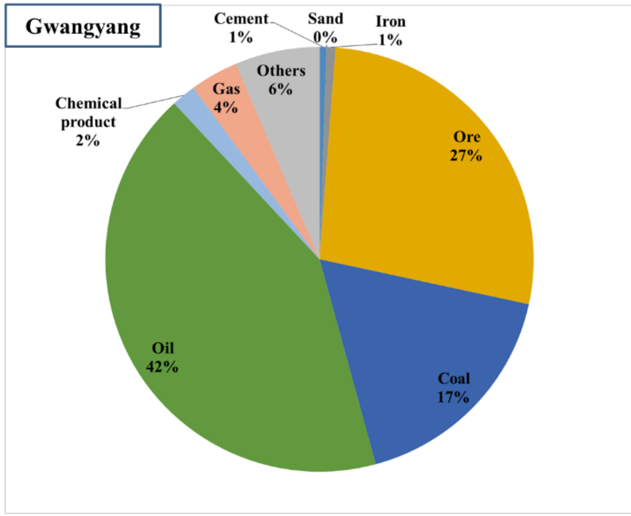
Cargo type	R/T (k tonnes)
Total	64,098
Cement	9
Sand	17
Iron	6,001
Ore	866
Coal	11
Oil	252
Chemical product	3,536
Gas	50
Others	53,356



Cargo type	R/T (k tonnes)
Total	98,123
Cement	7
Sand	54
Iron	4,722
Ore	2,775
Coal	15,166
Oil	10,572
Chemical product	1,585
Gas	24,351
Others	38,891



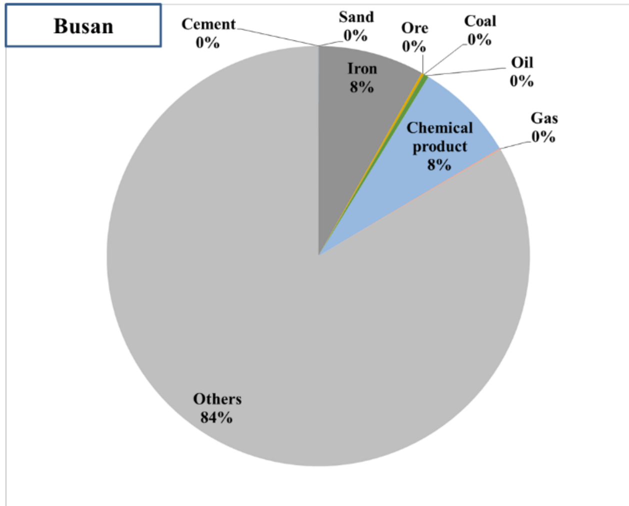
Cargo type	R/T (k tonnes)
Total	102,758
Cement	0
Sand	308
Iron	907
Ore	4,819
Coal	1,804
Oil	78,815
Chemical product	6,340
Gas	3,994
Others	5,771



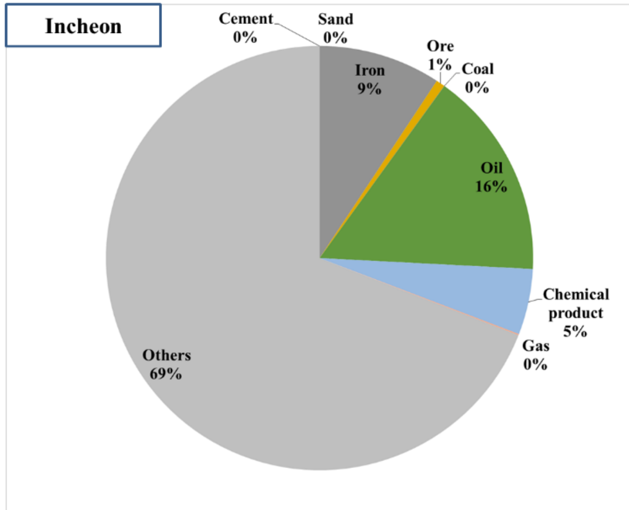
Cargo type	R/T (k tonnes)
Total	146,326
Cement	762
Sand	0
Iron	991
Ore	39,799
Coal	25,424
Oil	61,969
Chemical product	2,691
Gas	5,332
Others	9,358

Note: container freight and other products are classified as 'Others'. Source: compiled by the author from SPIDC (2017).

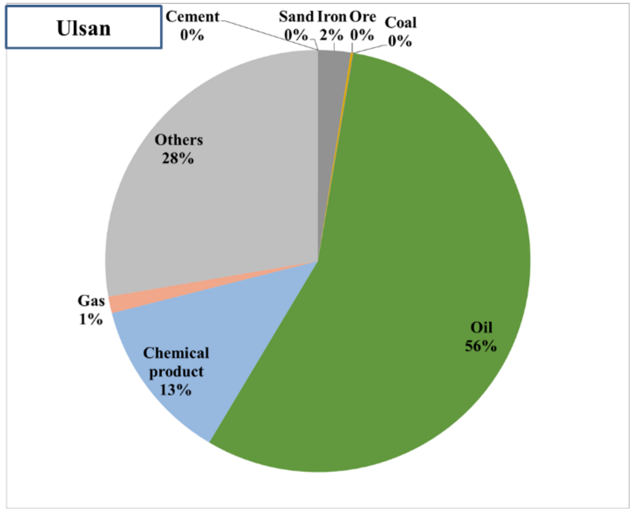
Figure 3-14 Compositions of the types of exported cargo traffic in four major ports in 2015



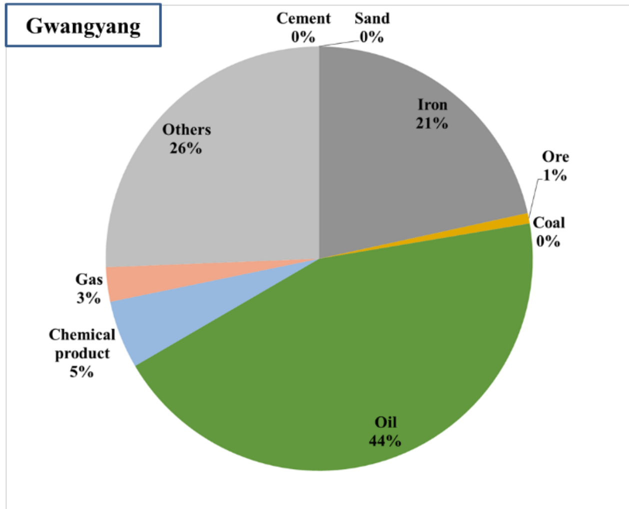
Cargo type	R/T (k tonnes)
Total	82,057
Cement	20
Sand	5
Iron	6,650
Ore	160
Coal	16
Oil	304
Chemical product	6,324
Gas	82
Others	68,496



Cargo type	R/T (k tonnes)
Total	24,733
Cement	0
Sand	1
Iron	2,287
Ore	167
Coal	3
Oil	3,928
Chemical product	1,240
Gas	22
Others	17,085



Cargo type	R/T (k tonnes)
Total	66,156
Cement	0
Sand	3
Iron	1,641
Ore	119
Coal	22
Oil	36,942
Chemical product	8,263
Gas	841
Others	18,325



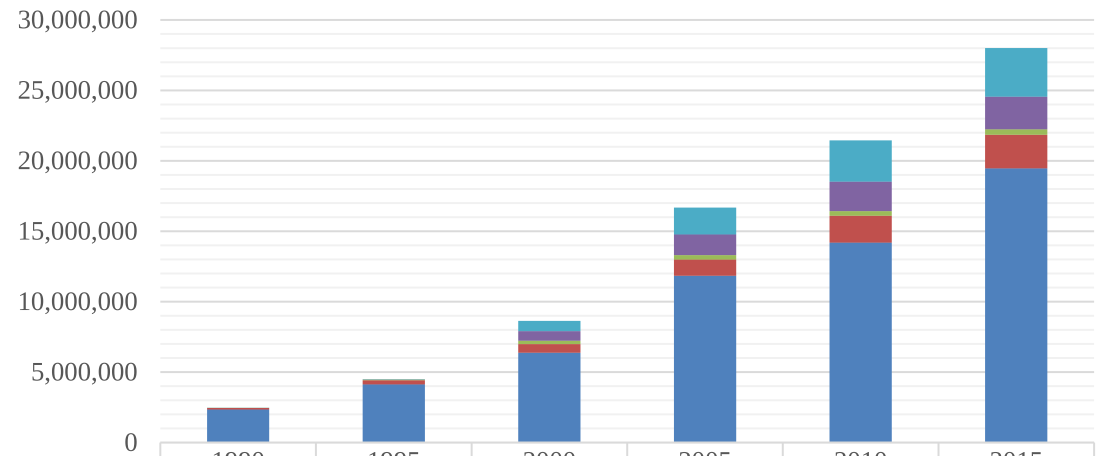
Cargo type	R/T (k tonnes)
Total	61,028
Cement	0
Sand	0
Iron	13,151
Ore	482
Coal	4
Oil	26,984
Chemical product	3,160
Gas	1,600
Others	15,647

Note: container freight and other products are classified as 'Others'.

Source: compiled by the author from SPIDC (2017).

Figure 3-15 Container traffic measured by TEU for the four ports.

(Unit: thousand tonnes)

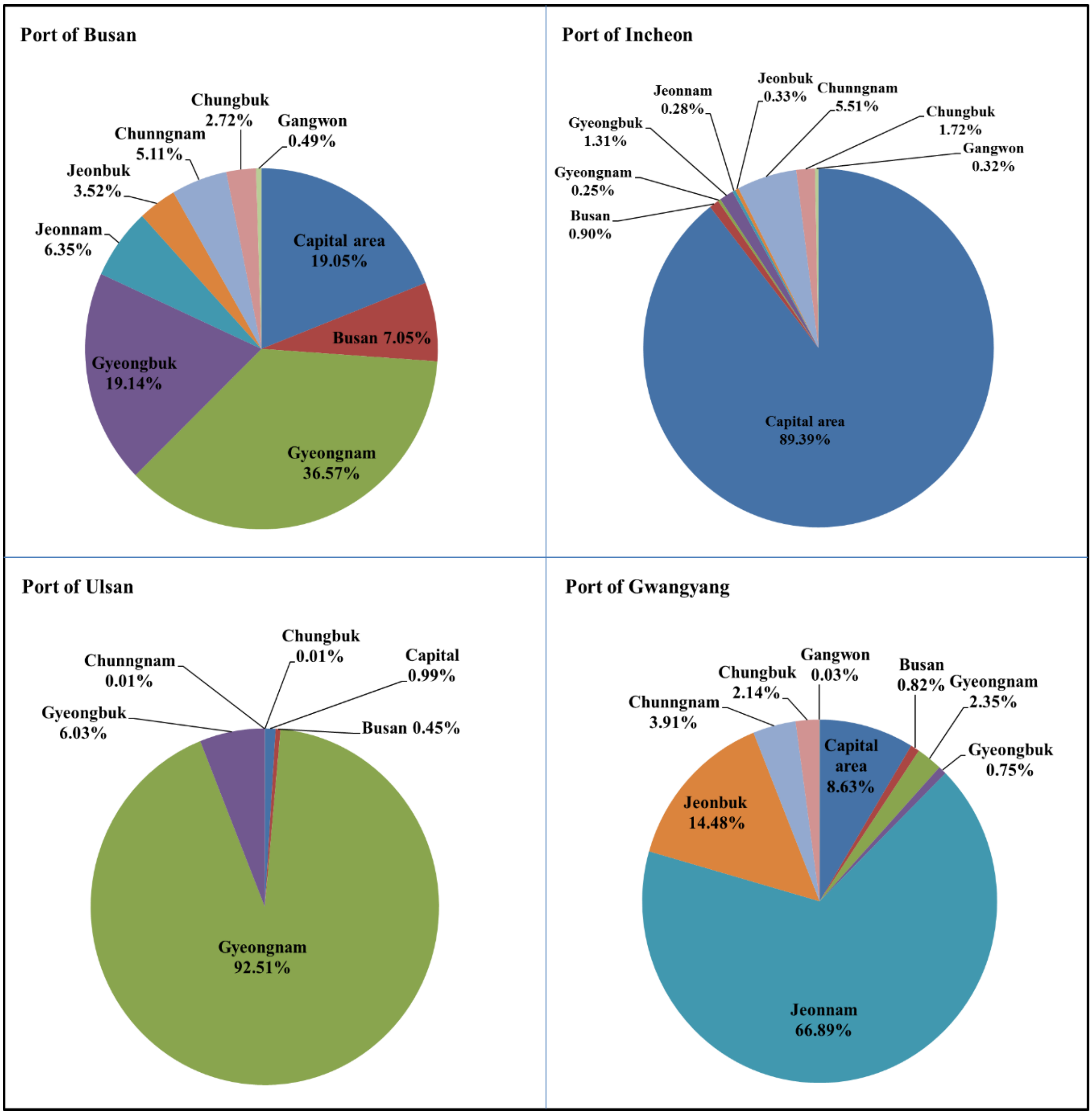


	1990	1995	2000	2005	2010	2015
Others	253	19,173	728,507	1,908,211	2,936,187	3,449,601
Gwangyang	0	11,826	677,747	1,460,818	2,087,890	2,327,335
Ulsan	7,394	42,567	236,296	316,432	335,706	385,208
Incheon	112,472	296,225	611,261	1,148,666	1,902,733	2,376,996
Busan	2,348,475	4,130,099	6,382,737	11,843,151	14,194,334	19,468,725

the Port of Busan has positioned as the greatest port in South Korea as shown in Figure 3-15. Even though the occupancy of the Port of Busan has decreased to around 75.8%, the Port of Busan has significantly higher proportion and greater amount compared to the other three ports. The Port of Incheon ranks at the second position in both the amount and the ratio of container freight, while the Port of Gwangyang and the Port of Ulsan are following.

Thirdly, in the sight of the service boundary of individual ports, the freight type is quite important according to KOTI (2005). It suggests that container cargo have a much broader spatial boundary for services than the bulk cargos: especially, in the sight of transportation distance. In other words, the four ports have a different portfolio in the sight of the origination and the destination of port freight. In the case of liquid cargo and dry bulk cargoes, the users of each port are located mainly around the industrial complexes nearby the port and nearby the city. On the contrary, in the case of container freight, the users of the four ports are scattered all over the country even though they are usually concentrated in the area close to each port. Figure 3-16 shows the regional composition of container freight by a port. In the case of the Port of Busan, the freights from and to Busan, Gyeongnam, and Gyeongbuk accounts for about two-thirds of the total container freight. Meanwhile, about 20 % of the total container freight is from and to the capital area. In the case of the Port of Incheon, more than 95% of the total container freight, including about 90% generated in the capital area, is from and to the vicinity of the Seoul metropolitan area. In the case of the Port of Gwangyang, about 80% of freight is generated in Jeonnam and Jeonbuk, which are close to the port, and the freight generated the former and the area inside of and nearby Ulsan in case of the latter. Furthermore, as considering

Figure 3-16 Regional compositions of container cargos of the four ports



Source: compiled from Appendix 2 Contextual Understanding fo the Four Major Ports.

in the capital area is about 9% of the total container freight. In the case of Ulsan, the freight generated in Gyeongnam, Gyeongbuk, and Busan accounts for 99% of the total.

Lastly, based on the results above, it can be inferred that the four major ports have quite a different role and status in the nation port systems. On one hand, in the sight of the service boundary, the Port of Busan and the Port of Gwangyang has supplied the service to all over the country even though more than two-thirds of the total volume is concentrated in several administrative regions which are comparatively close to the port. In addition, the Port of Incheon and the Port of Ulsan have played their role as a local or regional gateway to cover adjacent regions: namely, the capital area in case of the amount of container freight in individual ports, the Port of Busan can be evaluated to maintain its status as the gateway port in Korea, while the Port of Incheon and the Port of Ulsan can be said to play its role as the entry for the city and the economic region. The Port of Gwangyang is interpreted mainly to focus on handling the cargoes from and to the surrounding areas, but to play a role partially as the gateway in Korea. On the other hand, in the sight of the relationship among four ports, it can be concluded that general bulk cargos are handled at the port close to the origination and/or the destination but the container freight in Korea is handled mainly with the Port of Busan centred (KOTI, 2005). By this characteristic of the transportation distance, four major ports have its own independent service coverage in case of general bulk cargos but have been in a somewhat competitive relationship with regard to the container freight (Lee et al., 2009). For example, the Port of Incheon can be evaluated to compete for the freight in the capital area with the Port of Busan and the Port of Gwangyang. Meanwhile, the Port of Ulsan is estimated to compete with the Port of Busan for the freight in Gyeongnam area adjacent to Ulsan and Ulsan. On the other hand, the Port of Gwangyang is evaluated to compete with the Port of Busan and the Port of Incheon to attract the freight in the capital area and the middle area of Korea.

3.4.3 Summary

In this sub-section, this study discusses both the commonalities and the differences based on the results of a comprehensive understanding of individual ports in Appendix 2 Contextual Understanding of the Four Major Ports. In detail, the four ports have their own footprint in the four aspects: the chronological sight, the topographical aspect, the interaction with the city and the status in the ports systems. Based on the understanding of the features, this study introduces the findings in the next section.

3.5 Findings

3.5.1 Features in national port systems

In this chapter, an overview is provided with respect to the status of the ports in transportation, the ports in general and the four major ports. Based on this overview, it can be summarized that the Korean port system has several unique characteristics at the level of national port system comparing to the port system in other countries.

First of all, the public sector; especially, the central government, has led the history of the port development. Central government played a key role with regard to the port development in the 1980s when the ports had were developed in line with the central government's economic development strategy (KPHA, 2011). The role of the central government is still very important in the development and management of the port facilities; the central government consistently plays its role as a provider of port facilities, even though the authority and the responsibility have been devolved for the last several decades (Lee and Lam, 2017). It is clear that the port-related issues are closely in relation to the regional and/or local port community rather than the central government in South Korea. It is quite different from the ones in European countries; especially, UK (Brooks and Pallis, 2012).

Secondly, the Korean ports grew rapidly in a relatively short period of time compared to the ports in European countries; especially, ports in the UK (Bird, 1963). The Port of Busan and the Port of Incheon, which was opened at the end of the 19C, had been set gradually and have been modernized for a half of century. However, the ports which began to be developed in earnest as industrial ports in the modern era have a history of fewer than 50 years (KPHA, 2011). This can be evaluated as the result of the Korean government's strategic investment in port facilities under the export-oriented economic growth strategies. During this period, the government has been trying to keep the principle of selection and concentration in order to expand the port facilities efficiently under the shortage of government’s financial resources (MOF, 2016a).

Thirdly, in the sight of the evolutional procedure, the Korean ports seem to show a considerable difference from the ports in European countries. The ports which were opened in the 19th century: the Port of Busan, the Port of Incheon, and the Port of Mokpo, have been growing through the similar process of the ports in European countries. According to the ‘Anyport model’ of Bird (1963) focused on the cargo composition, most ports in European countries have developed through the several steps just like the settlement of a port, the growth of cargo volume, the enlargement of the port facility, and the specialization of the port facility for cargo type. However, Korean ports which have the several decade histories of modernization have evolved quite rapidly in line with the principle of the specialization of the government’s economic growth strategies (KPHA, 2011). As a result, these ports have followed unique evolutionary processes[58] of the settlement of a port, the specialization of cargo type, the enlargement of the port facility, and the diversification of cargo types. This is mainly because most of the ports which were developed in Korea's economic growth period are either to support specified industrial zones or to support specific coastal corporations[59].

Lastly, in terms of stakeholder relations, the Korean port governance is quite complex as a network of port authorities and port stakeholders and is in the various conflicts among the ports compared to the port governance in European countries. As mentioned by Wang et al. (2004), as the spatial extent of the port governance hierarchy expands, the scope of stakeholders generally broadens and the interests become more complex. In conclusion, this difference is based on the structural characteristics of the port governance that the central government has the authority and the responsibility with regard to port development and port management in most trade ports; especially, the central government is generally involved in the decision making even of four major ports' policies (Lee, 2009). As a result, policy decisions on specific ports affect stakeholders in nearby or rival ports and the proper management for stakeholders is required not only in a port but among ports.

3.5.2 Features in four major ports

A huge body of port studies present various suggestions with regard to what economic effects ports make and what role they play in relation to a regional economy with the different methodologies applied (Dooms et al., 2015). In the line of previous studies, this study presents the commonalities and the differences among four major ports and suggests some features as follows.

Firstly, in the perspective of the port development model, every four ports clearly have accumulated the individual footprint while adapting or adjusting the influences from the environmental factors such as geographical features, social and economic conditions (Lee and Lam, 2017). The Port of Busan and the Port of Incheon, which had rooted in the fishing port but have been developed as a commercial port, can be evaluated to have followed the classical three-stage development model of setting, expansion, and specialization. However, the Port of Busan and the Port of Incheon seem to have undergone the different stage of development while constructing port facilities at the new port after the 2000s. The Port of Busan has entered the new stage of 'new port' which is not able to be classified in the classical three-stage model since the mid-2000s when the New Port began to be

[58] Some ports like the Port of Pohang and the Port of Daesan have been developed at the coastal area far from existing port sites which were generally a fishing port. So some ports can be said to skip the step of the settlement and jump to the phase of the specification.

[59] The industrial ports have been developed with an overwhelming proportion of several specific cargos depending on the development purpose of the port. And then the composition of cargo has been diversified with the increase of other cargoes as the port grows. For example, the Port of Ulsan and the Port of Daesan are highly dependent on oil cargo and the Port of Pohang and the Port of Gwangyang are closely related to bulk cargo for POSCO.

operated. The Port of Incheon is understood to be in the third stage of ‘specialization’ in the sight that the facilities in the New Port have been constructed under the goal to complement the existing facilities. On the other hand, the Port of Ulsan and the Port of Gwangyang have quite different characteristics compared to the Port of Busan and the Port of Incheon. The former ports also had rooted in a fishing port but have been developed as a commercial port after functioned as an industrial port. For this reason, the two ports have stepped the different development trajectory that simultaneously features the second stage of ‘expansion’ and the third phase of ‘specialization’. In other words, the facilities in the two ports have been developed in the way that the expansion proceeds based on the specialization according to the cargo type such as liquid cargos, dry bulk cargos and the products.

Secondly, the four ports have interacted with their cities continuously but in the different relationship according to the phase of the port development. The Port of Busan and the Port of Incheon have contributed to the spatial enlargement and the economic growth of the city as an engine to play various roles such as providing jobs, attracting population influx, and supplying various urbanized infrastructures. However, the port and the city have been in the heavy conflicting such as road congestion, shortage of space, and environmental pollution through passing the stage of ‘expansion’. Especially, the spatial needs for port facilities conflict the ones for the urbanization like housing and commercial area. The development of facilities in the New Port as a solution to these conflicts has weakened the interface between the port and the city in the area nearby the existing port district and enlarged the new interface around the area of the New Port. On the other hand, the Port of Ulsan and the Port of Gwangyang have a relatively weak direct relationship compared to the first two ports. This is because the port facilities in the last two ports had been developed in order to support unloading the raw materials and loading the intermediate goods and the products generated in the industrial complexes nearby the port district. As a result, the two ports have formed an indirect relationship with the city that the interface is located between the coastal industrial complex and the urbanized area rather than the direct relationship that the interface is located between the port district and the urbanized area. Meanwhile, the port began to have the direct interface with the city and to contribute the economic growth of the city since the 2000s when the container dedicated facilities in the Port of Gwangyang and the New Port in Ulsan are developed.

Lastly, the features discussed above are clearly seen in the sight of the cargo composition and the service boundary port function and role. The Port of Busan and the Port of Incheon depends on the cargos generated outside of the port city. Meanwhile, the Port of Ulsan and the Port of Gwangyang have a very high proportion of cargos originated from nearby industrial complexes or major manufacturing companies such as the Hyundai Heavy Industry, Hyundai Motors and POSCO. This feature was also confirmed in the type composition of the cargos handled in individual ports. In the case of the Port of Busan and the Port of Incheon, container cargos, which handle the intermediate goods and the products, account for much higher proportion rather than the raw materials such as crude oil and iron ore. On the contrary, the cargo composition in the Port of Ulsan and the Port of Gwangyang shows the opposite pattern compared to the Port of Busan and the Port Incheon.

The key findings discussed above are focused on the spatial perspective. However, it is expected that individual ports have similar features in the sight of the industrial structure of their regional economy as shown in the cargo composition and the spatial distributions of users. For this reason, the economic effects of the ports in the sight of the industrial structure are necessary to be discussed in more detail in the next chapter.

Chapter 4 Research Methodology

4.1 Introduction

Nowadays, there is no doubt that it is an important area in the port studies to analyse the economic impacts of the ports. Indeed, many researchers present the socio-economic impacts with the various methodologies applied, even though the little consensus is shared in the sight of the methodology and the functional scope of the port-related activities (Dooms et al., 2015). A huge body of the PISs suggest that the ports have been functioned as a booster of the economic development for a region; at the same time, have caused the negative impacts mainly in the case of the developed countries (Park and Seo, 2016, Danielis and Gregori, 2013, Benacchio and Musso, 2001).

Despite large contribution to understanding the socio-economic impact of the ports, the PISs have faced the critical debates that the economic impacts are generally overestimated. As discussed by Dooms et al. (2015), the common problem is due to several features of the PISs: especially, due to the arbitrary classification of port-related activities and/or the duplicate inclusion of direct, indirect and/or induced effects. As well, it comes from the fact that the regional economic impacts are examined with the data from the port, even though the port variables cannot reflect the information related to the industrial changes such as containerisation and the vertical integration in a logistics network etc. (Ducruet et al., 2015). On the other hand, as discussed in the literature review, the PISs have the drawback not to show the structural changes in the economic impacts over time. This is mainly due to the methodological features: especially, both the IO analysis and the econometric analysis can supply no information about the structural changes in the port-related activities.

For these reasons, this study intends to set the research strategy as considering the debates in the PISs and the research objectives: especially, applying the multi-methodologies in which a classification of the port-related activities is not requested. In detail, this study introduces what the research gaps and the research strategy are in the next section; focused on the methodologies and the research scope. Secondly, the shift-share analysis is reviewed, as the first main methodologies, in the third section. The shift-share analysis is useful to understand the structural changes in transportation (Notteboom, 2010) and the sub-sectors in transportation with the data by the Standard Industry Classification (SIC) applied. Fourthly, the econometric analysis; especially, the regression approach based on the economic theory is introduced in the fourth section. In the section, why this study selects the econometric analysis.[60] and what specified model this study applies are discussed. Lastly, this study introduces the procedure of the empirical analysis in the last section.

[60] Some other methodologies which this study considers applying as the second methodology are introduced in the Appedix 2.

4.2 Research Design

The research design functions as the action plan which puts the research questions into shape and shows the outline of the research procedure (Robson and McCartan, 2016). In other words, it is the specified plan for how to answer the research questions so generally contains the clear objectives, which are derived from the research questions, the research strategy, the data collection techniques and the analysis procedure (Saunders, 2011). In this line, this study introduces why, for what and how the empirical analysis is conducted in order.

4.2.1 Research questions

According to Saunders (2011), a good research design is a strategic plan for efficiently achieving the research objectives which starts by clearly clarifying the research questions. In this line, this study compresses the key research questions, based on what is reviewed in the previous chapters, before jumping to the research objectives.

This study reviews the theoretical trends of studying what factors contributing to developing the ports and what role the ports play in the transport networks; especially, the changing role and status of the ports are expressed well in the title of the paper, by Pettit and Beresford (2009), "port development: from gateways to logistics hubs". A considerable body of the port studies recognises the role of the port as an integral component in the transport networks or the global logistics chains, due to the vertical and horizontal integration with strategic partnerships and co-operation arrangements (Bichou and Gray, 2004). As well, some researchers focus on the spatial enlargement and integration between the port district and the inland distribution centres far from the port region by extending the services (Notteboom and Rodrigue, 2005, Monios and Wilmsmeier, 2012a). Other researchers have lots of interests in the functional importance as the centre in the global supply chains through adding some value-added services on its conventional role (Bichou and Gray, 2005, Mangan et al., 2008, Pettit and Beresford, 2009). However, the existing PISs have the technical constraints for understanding whether the structural changes happen or not and examining what economic impacts they bring.

Based on the research gaps, this study has several research questions as below:

- How can an empirical study examine whether the structural changes in the port studies took place in practice or not?
- How can the PIS show what economic impact the changes have brought in the statistics?
- What methodologies can efficiently show the changes and the impacts both at the national level and at the regional level?
- Are the answers for the above able to be supplied with the data from regions accounts applied?

4.2.2 Research objectives

The research objectives are derived mainly from the research questions as follows;

- To examine whether the structural changes happened in practice or not in the port systems at the national level and at the regional level
- To show what economic changes both in transportation and in its four-subsectors as a proxy for the port economic impacts at the national level and at the regional level
- To suggest the methodological alternative for examining the features in the longitudinal changes and in the cross-sectional changes
- To conduct the empirical analysis with the secondary data from regional accounts both at the national level and at the regional level.

The research objectives are in the form of answering the research questions in order. The main aim is to clarify if the structural changes: so-called, the vertical integration, the horizontal co-operation, the port regionalization and the centralization of the ports in the supply chains happened in practice in the port system in South Korea. On the other hand, the other three objectives are more closely related to the methodological issues in the PISs: for example, the over-estimation of the economic impacts due to the arbitrary classification and the limitation of the longitudinal analysis and the cross-sectional analysis. The issues related to the latter are discussed while reviewing the methodologies in the later section

4.2.3 Research strategy

The main goal is to examine whether the structural changes in the port-related activities took place in practice in South Korea. The changes such as the intensification of the functional integration and the spatial enlargement of the port-related activities may bring the redistribution of the economic contribution of ports between the activities and the regions. In other words, the activities integrated with the port-related activities and the regions with the ports embedded in the supply chains may get more economic benefits under the changes but the regions with the ports weakly related to the supply chains may experience some outflow in the value-added.

On the other hand, this changes may result in the greater differences in the sectoral structure of transportation and regional economies. If this happened, the conventional approaches in the PISs may not be free from the risk of overestimation and underestimation of the economic impact. This study will discuss the further details in the later section. However, as discussed in the previous chapter, it is quite difficult to achieve the core objective with a specific methodology applied in the PISs. For this reason, this study tries to reach the goal by applying several different methodologies from the port level to the regional level.

4.2.3.1 What methodologies to be applied

The methodologies applied in this study are largely categorized into two methods of the shift-share analysis and the econometric analysis although some quantitative analyses such as the correlation analysis are applied to support the two methodologies. The methodologies are briefly reviewed in this part but the shift-share analysis and the econometric analysis in detail are reviewed in the third section and in the fourth section respectively.

4.2.3.1.1 Understanding of port system in general

As argued by Lee and Lam (2017), the port system at the national level would better be looked over in relation to various environmental factors as a part of the country's geo, political, economic and social system. In addition, a port system at the regional level, as a partial system of its city which various activities and various stakeholders take place as a place (De Langen, 2006), has evolved both while interacting with the city (Charlier, 1992, Hoyle, 2000a) and while functioning in the global economic system (Hall, 2008). In other words, for better understanding of individual ports, it is necessary to understand them not only by themselves but also in relation to the surroundings of the ports (Wang and Slack, 2002), based on the overall understanding of the national systems which the port is encompassed (Lee and Lam, 2017).

This study put several steps for comprehensively understanding of the four major ports based on the overview of the ports systems at the national level in chapter 3. In the hierarchical sight, this study implements the contextual understanding both by individually analysing ports with several methodologies applied and by comparatively analyising the features of the four major ports, as discussed in Appendix 2. In the methodological sight, this study applies several methodologies at the port level discussed in the literature review: for example, the port development trajectory (Bird, 1963, Notteboom and Rodrigue, 2005), the changes in the interface between the port and the city (Hayuth, 1982b, Hoyle, 1989), and some quantitative methods for examining the changes in the port variables (Ducruet, 2011). Then, the comparative study is conducted by using the results of understanding of the four individual ports. These results are discussed in the chapter of the contextual analysis.

4.2.3.1.2 Shift-share analysis

This study applies the dynamic approach of the shift-share analysis in order to understand the changes both in transportation as an industry and in the four sub-sectors of transportation at the regional level. The specified model, based on the work of Barff and Knight III (1988), can be formulated as below:

$$\sum_k d_{ij}^k \equiv \sum_k \Delta E_{ij}^k \equiv \sum_k g_{ij}^k + \sum_k k_{ij}^k + \sum_k c_{ij}^k \qquad 4\text{-}1)$$

where k is sub-periods and the others are same above.

What is important in the application of the dynamic approach is to decide how long the applied sub-period is.[61] Generally speaking, the dynamic one was likely to adopt the long sub-period by a decade or longer period (Barff and Knight III, 1988) by the 1990s but has a tendency to apply the shorter sub-period since the 2000s thanks to the development of the computation (Herath et al., 2011). When several pairs of long sub-period are applied, the dynamic approach has strengths in the points: to cut down the cost in time, to minimize the uncertainty from temporary changes and to focus on the structural changes for long periods. On the other hand, it also has the drawback that it supplies limited information related to the recent changes in surroundings. By contrast, when a number of fair of short sub-period are applied, the dynamic approach has the opposite strengths and drawbacks in the case of the former. In other words, the latter is very useful for understanding the changes between the small-time laps. As well, the sub-period, in the area of choices, can be selected as considering the objectives of the research and the cost (Herath et al., 2011). In conclusion, this study applies a year sub-period in order to investigate the annual changes in the GVA per worker.

On the other hand, this study implements the shift-share analysis with several steps applied. Firstly, this study analyses the changes in the GVA per worker of transportation in the four major port regions with the shift-share analysis applied. Secondly, this study repeats the analysis to examine the changes in the GVA per worker of the four sub-sectors in transportation in the four regions. The results from the two steps are introduced in the Appendix. Lastly, this study conducts the comparative analysis based on the above results. The results of the shift-share analysis are discussed in the chapter of the shift-share analysis.

4.2.3.1.3 Econometric analysis

This study applies the econometric analysis in order to examine the statistical relationship of port variables with the economic growth at the level of a region. The econometric analysis, based on the economic growth model and applied in the previous port studies, uses the specified regression function as follows:

$$\ln y_{it} = \beta_0 + \beta_1 \ln(n_{it} + g_{it} + \delta_{it}) + \beta_2 \ln s_{k,it} + \beta_3 \ln s_{h,it} + \beta_4 \ln y_{it-1} + \beta_5 \ln rd_{it} + \gamma \ln X_{it} + u_{it}. \quad \text{4-2)}$$

where $\beta_0, \beta_1, \beta_2, \beta_3, \beta_{4,}\gamma =$ coefficients, $X_{it} =$ port related variable, u_{it} = the region-specific error term.

This study utilizes the panel data for regressing the independent variables and the dependent variable. Even though this study is in line with the previous studies such as Bottasso et al. (2013), Shan et al.

[61] The details with regard to the shift-share analysis: especially, the dynamic approach of the shift-share analysis, are introduced in the next section.

(2014) and Park and Seo (2016) etc., this study has the originality in the methodological sight. On one hand, this study employs the sub-group analysis[62] in order to estimate several coefficients so that supplies the profound information with regard to the statistical relationship between the port variables and the economic growth.

On the other hand, this study also conducts the econometric analysis for time-series data by region. In other words, individual time-series data of the four major port regions are regressed and the coefficients are estimated by region. Then, this study interprets the results from the three different applications of the econometric analysis and derives significant meanings focused on the economic contribution of the ports to the regional economies.

4.2.3.1.4 Connection between the methodologies

The methodologies have few commonalities in the technical and structural sights. However, this study tries to make a connection between the methodologies even though the relationship is indirect. Firstly, understanding of port system in general is conducted mainly at the level of a port even though this study put the stress on the relationship between the port and the city. This step will supply some significant information for understanding the characteristics of individual ports in the spatial and economic sights. The results can be the key factors of the regional difference in the GVA per worker of transportation analysed by the shift-share analysis.

Secondly, the shift-share analysis is fundamentally the static methodology to show the characteristics in the economic changes in the sight of a sector and a region. This study, as a proxy for the economic performance derived from the port, focuses on the changes in the GVA per worker of transportation. This is rooted in the insight that the regional disparity may be getting bigger in the GVA per worker of transportation if the vertical integration and the concentration have proceeded in the activities in the transport networks or the supply chains. As a result, the results of the shift-share analysis shows the structural features of transportation in the regional economies.

Lastly, the econometric analysis is applied for the variables, which are structured as the panel data or the time-series data in individual regions at the level of the regional economy.[63] The results from the previous analyses must supply some significant implications with regard to the application of the econometric analysis and the interpretation of the estimators.

[62] This study applies the sub-period analysis, which the whole data are grouped into three different periods and the coefficients are estimated by sub-period, and the sub-region analysis, which the data are grouped into the regions with large-scale ports and the regions without large-scale ports and the coefficients are estimated by sub-region.

[63] The variables have the broadest boundary at the sight of the spatial scope compared to the variables in the contextual analysis mainly at the port level and the variables in the shift-share analysis at the level of an industrial sector.

4.2.3.2 What to be analysed

What the economic impact of ports is in the area of subjectivity with two different issues: what the best proxy is and what the good boundary is. In other words, the definition of the economic impact of ports is converted to selecting of the variable as a proxy and distinguishing of the industrial sectors affected by the ports (Benacchio and Musso, 2001). This study will discuss what and how to analyse in detail considering the overview of the PISs and the research objective.

4.2.3.2.1 Variables

As discussed in the chapter of literature review, in the theoretical aspect, the key variable is generally selected by the research methodology such as models of port demand, the economic base approach, Keynesian Income-Expenditure approach, Input-Output approach, and Location Quotient. However, the research methodology in the empirical studies is mainly based on the IO analysis and the econometric analysis. In the case of the former, both input variables like employment and output variable kike GDP and GVA seem to be adopted. On the other hand, in the case of the latter, output variable is applied as a dependent variable. In fact, the case studies in the recent decades tend to apply the GDP or the GVA as a proxy of port economic impact: especially in the case of the regression analysis. This trend can be interpreted as the reflection of the research implication that ports or port activities are getting capital-intensively more and more (Benacchio and Musso, 2001).

In addition to this research trend, this study tries to apply two different and independent methodologies for understanding of the economic effects of the structural changes in port-related activities. For these reasons, this study focuses on the variables of transportation in SIC as a proxy of port activities and independent variables in the econometric analysis. This is the reflection of the research objective not to evaluate the exact magnitude of the economic impacts of ports in a specific time period but to understand the changes and the trends of them over time.

4.2.3.2.2 Research boundary

What this study analyses can be clarified in the points of the functional boundary of the port-related activities, the geographical boundary and the time scope. First of all, the industrial boundary of port economic impacts is quite different mainly by the methodology. In the case of the IO analysis, the impacts are summed up three typical effects such as the direct effects, the indirect effects, and the induced effect. As a result, it is not possible to clarify what the sectoral boundary before research have been done since classifying three different effects is the key part of empirical analysis. On the other hand, in the case of the econometric analysis, the sectoral boundary of a dependent variable is generally different from the one of independent variables. Generally speaking, the boundary of the former variable tends to be the whole value in a regional economy but the one of the latter variables depend on the research objective and the data acquisition. This study will analyse the GVA per worker of both transportation and the four sub-sectors of transportation in the shift-share analysis. As well, this study will apply the regional GVA per worker in a regional economy as a dependent variable.

Secondly, the geographical scope is basically the administrative boundary of the regional government. In the PISs, it is quite important to decide what geographical boundary is applied: local, regional, national and international dimensions. The geographical scope depends not only on the research goal that the researcher wants to meet but also on the spatial boundary that the economic impacts take place (Coppens et al., 2007). Conventionally, the PISs have focused on the impacts at the level of the national economy rather than at the level of the regional economy in order to attract financial investments on port projects: however, the PISs are more likely to be implemented at the dimension of regional economies (Dooms et al., 2015). This study also conducts the empirical analysis at the regional dimension, as considering the trend in the PISs and the limitation with regard to the data acquisition[64].

Lastly, the PISs are generally divided into two groups: a static analysis and a dynamic approach. It is clear that a dynamic approach provides more significant information about the longitudinal trend however a static one supplies more abundant information related to the magnitude and the relationship with other industries (Coto-Millán et al., 2010). This study applies a dynamic approach, considering the objectives of the research which are focused on understanding the structural changes in transportation over time rather than estimating the magnitude of the whole economic impacts at a specific time.

4.2.4 Data acquisition

As shown in Table 4-1, various types of historical data such as maps, figures, and the panel data from regional accounts, are necessary to implement the multi-methodology analysis. Especially, it is indispensable to acquire the high quality of the panel data, which consist of 16 sectoral values in 16 regions for 25 years. This study clarifies the data source as follows. Firstly, this study uses the documentary data from the various websites[65] of the Korean government: Korean Statistical Information Service (KOSIS), Economic Statistics System of the Bank of Korea (ECOS), Ministry of Land, Infrastructure and Transportation (MOLIT), and Ministry of Oceans and Fisheries (MOF) etc. The data from the websites are basically in the form of the electronic file but some of them are

[64] In South Korea, Regional account is based on the administrative district (Korea Statistic Agency).
[65] The websites are below:

- KOSIS (http://kosis.kr/), ECOS(http://ecos.bok.or.kr/), MOLIT(www.molit.go.kr), MOF(http://www.mof.go.kr/)
- Road Statistics and Maintenance Information System (http://www.rsis.kr/), Shipping and Port Information Data Centre (https://www.spidc.go.kr:10443/).

Table 4-1 Sources of the raw data used for this study

Category	Variable	Type	Source
General information	Population of 16 regions	EF	KOSIS
	Area of 16 regions	EF	KOSIS
	Transport and logistics infrastructure	EF&HF	MOLIT
	Container port facility	EF&HF	MOF
	Port related statistics	EF&HF	MOF
Descriptive analysis	GVA per worker of 16 sectors in 16 regions	EF	KOSIS
	Employment in 16 regions	EF	ECOS
Shift-share approach	GVA per worker of 16 sectors in 16 regions	EF	KOSIS
	GVA per worker of four sub-sectors in transportation	EF	KOSIS
Econometric analysis	GVA per worker of 16 sectors in 16 regions	EF	KOSIS
	Real investment in a region	EF	ECOS
	University graduates	EF	KOSIS
	The number of economically active people	EF	ECOS
	Area of road in 16 regions	EF&HF	MOLIT
	Net area for distribution centre in a port	EF&HF	MOF

Note: EF; Electronic file, HF; Hard-copied file.

converted to the electronic file from the hard-copied data. Secondly, this study acquires the raw data by the 2010 price of the monetary value, which the websites supply in order to investigate the annual changes of GVA per worker by the same monetary value. Lastly, this study uses the panel data from the regional accounts so that each national value is obtained by summing the values of 16 regions.

4.3 Shift-share Analysis

4.3.1 Introduction

Shift-share analysis is such a popular technique among experts and researchers in various disciplines such as regional economics, geography, and regional science (Haynes et al., 2005, Nazara and Hewings, 2004, Dinc, 2002, Knudsen, 2000, Knudsen and Barff, 1991). Furthermore, the shift-share analysis is applied in a number of papers in the field of international economics; even in the area of politics and marketing from the 1990s (Chiang, 2012). It is not difficult to see the paper in port studies which applies the shift-share analysis in order to examine the output changes among ports and the economic contribution of the port to its city or region (Notteboom, 2010, Jung, 2014)

Why is the shift-share analysis such a widespread and affordable methodology? Firstly, it is quite simple and easy to implement with the modest raw data required (Blien et al., 2013, Haynes and Parajuli, 2014), but presents abundant and comprehensive information by the comparative changes as well as the absolute magnitude of a regional industry (Srivastava, 2010). According to Knudsen (2000, p. 178), "policy-makers who often need a quick and inexpensive analysis tool that is neither mathematically complex nor data intensive also utilize shift-share extensively". Secondly, it has such a powerful advantage to partitioning all changes to several effects from regional economy and national economy in the relationship between them (Haynes and Parajuli, 2014). Thirdly, it can analyse both the sectoral growth rate in a regional economy and the regional growth rate of a national industry (Artige and van Neuss, 2014). It is since the growth of the regional economy has strong relationships with the structure and the growth of the national economy in almost all countries, regardless of whether developed or developing (Dunn, 1960). Lastly, its widespread application is thanks to overcoming the limitations with enthusiastic debates and various extensions over time, in the light of both the lack of theoretical basis and empirical stability (Loveridge, 1994, Srivastava, 2010).

This research introduces the concept of the shift-share, based on the classical formulation, the debates, the dynamic approach[66] and the application in the port studies.

4.3.2 Classical shift-share analysis

The shift computation, which is back to Creamer' work in 1942, is to describe the geographical distribution of an economic performance between two different time periods (Dunn, 1960). After Dunn's work, the shift-share analysis has been utilized quickly thanks to its strengths of easy application but abundant information (Knudsen, 2000).

[66] Other extensions except for the dynamic approach are introduced in Appendix 3.

The original approach is based on the implicit assumption that a regional economy studied has the same industrial structure and the same market with a benchmark economy; the national economy is used as a benchmark economy compared with a regional economy (Dinc and Haynes, 2005). In addition, this analysis focuses on partitioning between sectors and regions, based on the assumption that each sector or each region grows at the same rate as the national economy, and separating the changes shared with the national economy and the ones shifted by specialisation and other factors of a regional economy (Blien et al., 2013). This can be understood as shown in Table 4-2. An actual indicator of each industry in a region (E_{ij}) is shifted from an expected indicator ($\sum_j E_{ij}$ or $\sum_i E_{ij}$) of each industry in a region in the structure of the national economy, so this discrepancy can be estimated by partitioning between industries and regions (Stilwell, 1969).

Table 4-2 Structure of the shift-share analysis

		Region j					
		←········		j	········→		Sum
Industry i	↑						
	⋮						
	i			E_{ij}			$\sum_j E_{ij}$
	⋮						
	↓						
	Sum			$\sum_i E_{ij}$			$\sum_i \sum_j E_{ij}$

Table 4-3 Comparison of the name of shift-share components

Researchers	**Share Component**	**Shift Component**	
	National Growth	Industrial Mix	Differential Effect
Dunn (1960)	(Expected Growth)	Proportionality Effect	Differential Effect
Houston (1967)	National Growth	Compositional Mix	Competitive Position
Ashby (1968)	National Growth	Industry Mix	Regional Share
Stilwell (1969)	Regional Share or National Growth	Proportionality Shift Industrial Mix	Differential Shift or Regional Shift
Esteban-Marquillas (1972)	National Growth	Industry Mix	Competitive Effect
Buck and Atkins (1976)	National Growth	Composition Components	Growth Components
Barff and Knight III (1988)	National Growth	Industry Mix	Competitive Effect

Source: compiled by the author from the papers in the table.

Even though the formulation is identity, researchers use a different name for the same content (Blien et al., 2013). As shown in Table 4-3, three components, especially two shift components, are named differently because each formulation has both the focus which a researcher has an interest in and the specific objective which a research targets on. The definition by Stilwell (1969) is quite useful to well understand the original concept of shift-share analysis because he separates the share which is allocated from the benchmark economy to a region and the shift which is generated in a region by its industrial composition and its other economic characteristics. However, in this research, the expressions which were named by Esteban-Marquillas (1972) are used because they show well the practical characteristic, as a regional economic analysis tool, which is that a national economy is the best as the benchmark (Loveridge and Selting, 1998) and the proportionality effect is calculated by industrial mix. In addition, it is good to be consistent in explaining the various extensions.

4.3.2.1 Two component model

Dunn (1960) suggested the two components model that separates the total changes into the proportionality effect and the differential effect by the absolute amount of employment between two periods, using the national economy as a benchmark.

The total shifts are computed as the discrepancy between the actual employment and the average growth of the national employment as an expected employment. The differential shift means the changes from any regional characteristics such as accessibility to raw materials or product markets, infrastructure and transportation. It is computed by the sum of a discrepancy between actual employment and expected employment of each industry in a region. It can be understood that the growing regions are enjoying an expansion in employment that is more rapid than for the same sectors in other regions (Dunn, 1960). On the other hand, the proportionality shift, which is the effects that occur from the industrial structures in a region, is computed as a discrepancy between the total shifts and the differential shift. The positive shift in the proportionality effect in a region means that the region specializes in the rapid growth sectors. Stevens and Moore (1980, p. 422) interpreted that "Dunn focuses on total shifts and introduces differential growth rates in individual industries only to obtain an accurate measure of total differential regional shift".

The total shift for the state is:

$$\boldsymbol{S_t} = \boldsymbol{E^*_{.j}} - (\boldsymbol{E^*_{..}}/\boldsymbol{E_{..}})\boldsymbol{E_{.j}} \qquad 4\text{-}3)$$

The differential shift for the state is:

$$\boldsymbol{S_d} = \sum_i \left[\boldsymbol{E^*_{ij}} - (\boldsymbol{E^*_{i.}}/\boldsymbol{E_{i.}})\boldsymbol{E_{ij}}\right] \qquad 4\text{-}4)$$

And, the proportionality shift is:

$$S_p = S_t - S_d = \left[E^*_{.j} - (E^*_{..}/E_{..})E_{.j}\right] - \sum_i \left[E^*_{ij} - (E^*_{i.}/E_{i.})E_{ij}\right] \qquad 4\text{-}5)$$

$$= \sum_i (E^*_{i.}/E_{i.})E_{ij} - (E^*_{..}/E_{..})\sum_i E_{ij}$$

$$= \sum_i [(E^*_{i.}/E_{i.}) - (E^*_{..}/E_{..})]E_{ij} \qquad 4\text{-}6)$$

Let E_{ij} = employment in the i-th industry and j-th region in the initial time period

E^*_{ij} = employment in the i-th industry and j-th region in the terminal period

$E_{i.}$ = national employment in the i-th industry (=$\sum_j E_{ij}$)

$E_{.j}$ = total region employment (=$\sum_i E_{ij}$)

$E_{..}$ = total national employment in all industry (=$\sum_i \sum_j E_{ij}$)

4.3.2.2 Three component model

The three-component model, which is suggested by Ashby (1964), is that the economic growth of a region is decomposed into three components; national share, industrial mix, regional shift (Stevens and Moore, 1980). This is another identity formulated from the two-component model, where total change is the sum of the propositional effect and the differential effect, through moving the effective growth to the right side of the formulation.

According to Stilwell (1969), the sum of two shifts in the two-component model means a net change in a region compared with the regional share, on the other hand, the sum of three components is the same with the actual growth of a regional variable such as employment, regional product, value-added, etc. The actual growth of a regional variable consist of one share component and two shift components as below (Dunn, 1960, Stilwell, 1969, Barff and Knight III, 1988, Loveridge and Selting, 1998, Knudsen, 2000):

- **The national growth effect (share):** the change given to a regional economy by the benchmark economy; usually, the national economy in the context that a regional economy is a part of the national economy. This measures the amount by which a region would have grown during the period studied, assumed that a regional economy grew at the same as the benchmark economy.
- **The industrial mix effect (shift):** the change generated from the differences in the industrial composition in a region compared to the one in the benchmark economy. This means the degree by which a specific region has a specialised composition in industries developing faster than the overall average of the national economy. This effect is measured by the difference between the growth of an industry in a national economy compared to the growth of the national economy.

- **The competitive effect (shift):** the change, namely residual, from all factors except for the national growth effect and the industry mix effect. This indicates the degree to which a region has a comparative advantage or disadvantage for each industry compared to the average of each industry in the national economy. This is calculated by the difference between the growth of an industry in a region and the one in the national economy.

What mentioned above, so-called national growth approach can be formulated algebraically as shown (Stilwell, 1969):

Total Growth in region j = Nation Growth + Total Shift (Industrial Mix + Competitive Effect)
(TG_j) (NG_j) (IM_j) (CE_j)

$$\boldsymbol{TG_{ij} \equiv E_{ij}^1 - E_{ij}^0 \equiv \Delta E_{ij} \equiv NG_{ij} + IM_{ij} + CE_{ij}} \quad 4\text{-}7)$$

$$\boldsymbol{TG_j \equiv \sum_i TG_{ij} \equiv \sum_i E_{ij}^1 - \sum_i E_{ij}^0 \equiv \sum_i \Delta E_{ij} \equiv NG_j + IM_j + CE_j} \quad 4\text{-}8)$$

$$NG_j = \sum_i E_{ij}^0 \left(\sum_i \sum_j E_{ij}^1 / \sum_i \sum_j E_{ij}^0\right) - \sum_i E_{ij}^0 \quad 4\text{-}9)$$

Total shift ($\boldsymbol{IM_j}$ + $\boldsymbol{CE_j}$) = $\boldsymbol{\sum_i E_{ij}^1 - \sum_i E_{ij}^0 \left(\sum_i \sum_j E_{ij}^1 / \sum_i \sum_j E_{ij}^0\right)}$ 4-10)

$$\boldsymbol{IM_j = \sum_i E_{ij}^0 \left\{\left(\sum_j E_{ij}^1 / \sum_j E_{ij}^0\right) - \left(\sum_i \sum_j E_{ij}^1 / \sum_i \sum_j E_{ij}^0\right)\right\}} \quad 4\text{-}11)$$

$$\boldsymbol{CE_j = \sum_i \left\{E_{ij}^1 - E_{ij}^0 \left(\sum_j E_{ij}^1 / \sum_j E_{ij}^0\right)\right\}} \quad 4\text{-}12)$$

where E_{ij}^t = employment in an industry i and a region j at time t (0: base time, 1: terminal time)
$\sum_i E_{ij}$ = employment in all industry in a region j
$\sum_j E_{ij}$ = employment in an industry i in all regions
$\sum_i \sum_j E_{ij}$ = employment in all industry in all regions (= total national employment).

The formulation above can be changed to the formulation, the national growth rate approach, which contains growth rates of the variable. Each formulation of equation 4-13), 4-14), 4-15) can be derived by changing individually the equation 4-9), 4-11), 4-12) to the form which is multiplied by $\boldsymbol{E_{ij}^0}$.

$$NG_j = \sum_i E_{ij}^0 \left(\sum_i \sum_j E_{ij}^1 / \sum_i \sum_j E_{ij}^0 - 1\right) = \sum_i E_{ij}^0 \times r_{oo} \quad 4\text{-}13)$$

$$IM_j = \sum_i E_{ij}^0 \left\{\left(\sum_j E_{ij}^1 / \sum_j E_{ij}^0 - 1\right) - \left(\sum_i \sum_j E_{ij}^1 / \sum_i \sum_j E_{ij}^0 - 1\right)\right\}$$

$$= \sum_i E_{ij}^0 \times (r_{io} - r_{oo}) \quad 4\text{-}14)$$

$$CE_j = \sum_i \left\{E_{ij}^0 \times \left(1 + r_{ij}\right) - E_{ij}^0 \left(\sum_j E_{ij}^1 / \sum_j E_{ij}^0\right)\right\}$$

$$= \sum_i \{E_{ij}^0 \times (1 + r_{ij}) - E_{ij}^0 (1 + r_{io})\} = \sum_i E_{ij}^0 \times (r_{ij} - r_{io}) \quad 4\text{-}15)$$

where E_{ij}^t = amount employed in an industry i and a region j at time t

r_{ij} = growth rate of employment in an industry i and a region j

r_{io} = growth rate of employment in an industry i in all regions

r_{oo} = growth rate of employment in all industry in all regions

4.3.2.3 The debates about the classical approach

Paradoxically, the widespread application of the shift-share analysis is attributed mainly to recurrent criticisms and defences (Houston, 1967, Thirlwall, 1967, Stilwell, 1969, Buck, 1970, Richardson, 1979, Fothergill and Gudgin, 1979). Loveridge and Selting (1998) appraised that Richardson (1979) is the most frequently cited of the shift-share criticisms which have been addressed by succeeding research. Recurrent debates can be categorized to five points: namely, the result's sensitivity on classifying industrial sectors, the problem of a base year, the instability of the competitive effect, shortage of a theoretical base, the interdependence of the industry mix and the competitive effects (Fothergill and Gudgin, 1979, Stevens and Moore, 1980, Loveridge and Selting, 1998).

The first criticism, which is acknowledged as a limitation by Dunn (1960), is that the result of the shift-share approach is highly sensitive to the industrial classifications; especially, the finer the industrial classification is, the bigger the industry mix and the smaller the competitive effect (Stilwell, 1969). However, according to a number of empirical studies (Fothergill and Gudgin, 1979, Casler, 1989, Loveridge and Selting, 1998), the result is not so severely biased as this approach should be abandoned. Loveridge and Selting (1998, p. 41) evaluated, as citing the work of Casler (1989), "it is inconsistent to single the shift-share out for criticism on the basis alone, since many commonly used regional techniques (e.g. location quotient, econometric models, GIS, input-output and CGE) are also sensitive to the level of aggregation".

The second issue, so-called 'the choice-of-weights problem', is that the industrial composition of a region must change over time and it causes incorrect allocation between the industry mix and the competitive effect; especially, the longer the period studied is, the bigger the bias is. So far, there are three choices; the weight of the beginning which was used by Dunn (1960), some average of the beginning and the end suggested by Fuchs (1962), and the final year weights suggested by Stilwell (1969). Meanwhile, in the different sight, Thirlwall (1967) suggested that the fitness of the results can be increased through investigating the change during sub-periods and Barff and Knight III (1988) suggested a dynamic approach to calculating the changes of each effect annually and analysing them more elaborately through summing and averaging. Furthermore, Loveridge and Selting (1998) state that the dynamic approach supplies a time series of the competitive effect, which can be used for forecasting and policy evaluation. As well, the dynamic approach can not only control the choice-of-weights problem inefficient but also solve the criticism of Brown (1969) that the competitive effect behaves unpredictably because it is extremely difficult to establish the 'correct base year' for analysis (Knudsen, 2000).

The third point is that the competitive effect does not show the stability over time and the degree of the stability varies between industries (Thirlwall, 1967, Brown, 1969, Richardson, 1979) because the competitive effect may be influenced by various factors; the incorrect classification of firms and transfers of production between separate sites of individual firms (Fothergill and Gudgin, 1979). This debate is important because forecasting models are extended to the way the competitive component is carried forward in time for forecasting (Loveridge and Selting, 1998), based on the assumption the competitive effect is random and follows the normal distribution (Berzeg, 1984, Arcelus, 1984). However, Fothergill and Gudgin (1979) insisted that in most cases the competitive effect tells a consistent story over time and it means that the instability of the competitive effect is just a problem in exceptional cases. Its instability over time is not so serious as shift-share analysis should not be used in forecasting (Loveridge and Selting, 1998).

The fourth problem is that the various components of shift-share formulation are not defined based on a theoretical background but induced from the identical equations; namely, the shift-share formulation cannot be tested on a theory or for prediction of the growth rates in regional variables because it does not have any endogenous variable (Houston, 1967, Buck, 1970, Richardson, 1979). From these rudimentary characteristics, the shift-share analysis can have developed to the various formulations according to researchers' practical objectives (Esteban-Marquillas, 1972), even though it has not supplied enough logical background about why the growth rates differ across regions (Loveridge and Selting, 1998). However, several researchers (Chalmers and Beckhelm, 1976, Sakashita, 1973, Casler, 1989) tried to explain each effect on the theoretical base like location theory, a multi-regional growth model, and a regional input-output model. Even though its theoretical lack is true, the fact that numerous practical studies have applied various formulations as the main analysis tool means that it is very practical and effective at least in the area of practical research regardless with the debate (Fothergill and Gudgin, 1979). Furthermore, the shift-share formulation can be useful for prediction of growth rates in variables through the derivation of estimable stochastic formulations (Berzeg, 1978, Arcelus, 1984)

The last point, raised by Rosenfield (1959), is that the values of the competitive effect are due to the specialisation of a region as well as its industrial composition (Fothergill and Gudgin, 1979). This error occurs because the industry mix and the competitive effect are interdependent of each other (Loveridge and Selting, 1998). Esteban-Marquillas (1972) suggested the new formulation to solve this problem by introducing the homothetic employment, which is the national economic structure as another benchmark and separating the existing competitive effect to the competitive effect and the allocation effect. On the other hand, Stilwell (1969) states that the result of Minimum List Heading classification was reasonable and the analysis at Standard Industrial Classification Order level may supply a very high explanation in practice.

Going through long and tough arguments, paradoxically, it became one of the most popular toolkits in regional economics and it is proliferating into various disciplines such as regional economics, international economics, and business (Loveridge and Selting, 1998, Oyewole, 2016). It is mainly because it is too powerful to abandon its advantages in reality where researchers cannot obtain enough deep and fine raw data to fit more elaborate analysis tools (Artige and van Neuss, 2014).

4.3.3 Dynamic approach of shift-share analysis

The dynamic approach stems from the suggestion of Thirlwall (1967) that the shift-share analysis with sub-periods would solve the problem of changing conditions during the period studied; the choice of weights, the correct base, and the interwoven relationship between the industrial mix and the competitive effect (Knudsen, 2000). Even though there are several studies (Brown, 1969, Fothergill and Gudgin, 1979, Danson et al., 1980) with sub-periods applied, it was not until Barff and Knight III (1988) that the dynamic approach analysed the annual shift-share effects.

Barff and Knight III (1988) show that the dynamic approach is very useful to eliminate the distortion from the time period through descriptively comparing the static shift-share analyses for the employment data with seven broad categories for 45 years. As well, Knudsen and Barff (1991) suggested the dynamic approach as an algebraic model, based on the Arcelus (1984) extension to separate the regional effect and the national effect with homothetic employment applied. However, for better understanding, this research overviews the formulation of the dynamic approach based on the classical model.

The formulation can be rearranged like the equation 4-16) by applying in a sub-period k (= the number of pairs of comparing years) and summing each component as below:

$$\sum_k \boldsymbol{TG_{ij}^k} \equiv \sum_k \Delta \boldsymbol{E_{ij}^k} \equiv \sum_k \boldsymbol{NG_{ij}^k} + \sum_k \boldsymbol{IM_{ij}^k} + \sum_k \boldsymbol{CE_{ij}^k} \qquad \text{4-16)}$$

where $NG_{ij}^k = E_{ij}^k \times r_{oo}^k$

$IM_{ij}^k = E_{ij}^k \times \left(r_{io}^k - r_{oo}^k\right)$

$CE_{ij}^k = E_{ij}^k \times \left(r_{ij}^k - r_{io}^k\right)$

E_{ij}^k = the number employed in industry i in region j at time k

r_{ij}^k = the growth rate in industry i in region j at time k

The dynamic approach has many advantages, compared to the classical static model although it requires lots of time and effort to gather and analyse the raw data (Barff and Knight III, 1988, Knudsen and Barff, 1991, Loveridge, 1994, Mayor et al., 2007). First of all, it supplies researcher flexible options to set the studied period; from annual to several years. As such, this approach supplies the abundant information by comparing various pairs of the sub-periods. Recently, a number of study analyses and updates annually the changes of three component effects through using annual growth rates. Secondly, this approach is very useful to eliminate the distortion from various factors: the choice of weights, the choice of correct base time, the changing composition of the industry, and the enlargement of an economic variable. Thirdly, this approach presents abundant information due to its characteristic which splits the study period to sub-periods and sums each change to obtain the total change: annual change, average change and total change of three components and even trend of annual change. Lastly, this approach is very transformable in terms of primary approach, from the simple classical approach to stochastic version, because the formulation of this approach is derived through splitting the study period. Meanwhile, Knudsen and Barff (1991) recommend that dynamic approach from ANOVA-based shift-share should be used carefully because it can be unstable when the result of ANOVA-based shift-share is pretty much different from the one of accounting approach.

According to Barff and Knight III (1988), when the research objective is to analyse past growth patterns, the dynamic approach is better than comparative static models. On the contrary, the former is inferior to the latter in the point of investigating the cumulative effects of regional policies. Furthermore, this approach is not appropriate to predict the change of variables in the future. Due to the advantages and the drawbacks above, the recent empirical studies applying this approach focus on both sub-periodic (e.g. annual, biannual, five-year period) change of each effect and its trend over time (Mayor et al., 2007, Herath et al., 2011, Huaxiong and Fang, 2011, Akkemik, 2011).

4.3.4 Application in empirical analysis

Even though there have been the intensive debates, there is an agreement that it is very useful and efficient. In the other context, this widespread application may mean that what is important is not whether it is appropriate as an analysis tool but how it is applied within its limitations, just as mentioned by Merrifield (1983). In this line, there are several empirical port studies applying this approach as shown in Table 4-4.

To speak generally, it can be said that the shift-share analysis might not be applied so early in the port study, but it must be a useful tool nowadays. According to Marti (1982), even though the shift-share analysis is very powerful to scrutinize port traffics, it had not been observed just in the literature of port study except for Rimmer (1965) who may be the first researcher to the apply shift-share analysis. As well, it is not until Marti (1982) that applies the three-component model to the port study. However, it is not difficult to find the paper applying the shift-share analysis since Notteboom (1997).

Table 4-4 Types of research using Shift-share analysis in Port Studies (various sources)

Researchers	Purpose of research	Applied approach	Remark
Rimmer (1967a)	Evaluating changes in the status among seaports through analysing the change of cargo tonnage in each port	Comparative static version of net shift approach (actual tonnage versus expected tonnage)	Evaluating changes in coastal tonnage of 35 ports in New Zealand between 1953 and 1963
Marti (1982)	Demonstrating advantage of the shift-share analysis as a tool for port studies and to support the decision-making process	Comparative static version of shift-share approach (two components)	Analysing changes in two indicators (total tonnage, import tonnage, and SIC commodity of Boston) among eight ports in New England for 11 years (1968~1978)
Notteboom (1997)	Evaluating concentration of the European container port system and discussing the factors affecting concentration pattern in the future	Dynamic version of net shift approach (four sub-periods by four or three years)	Evaluating absolute volume and concentration among ten container ports in Europe for 15 years (1980~1994)
Fowler (2006)	Showing the strengths of a network methodology using transport networks by analysing container flows	Dynamic shift-share approach by individual year	Measuring the change of container volume and the trend of trade proportion of six ports in US west coast for 11 years (1989~1999)
Marti (2008)	Analysing change of fossil fuel energy imported through ports in New England	Dynamic shift-share approach (three components)	Investigating competition and the trends of import tonnage of fossil fuel(eight categories by SIC) among eight ports in New England for ten years (1995~2004)
Notteboom (2010)	Updating of the former analysis by Notteboom (1997)	Dynamic version of net shift approach (seven sub-periods by one to five years)	Analysing container flows of top 15 container ports, six port ranges and 14 multi-port gateways in Europe for 24 years (1985~2008)
Fraser and Notteboom (2012)	Assessing the development paths of container port system through analysing the level of concentration / deconcentration	Dynamic version of net shift approach (eight sub-periods by two or five years)	Evaluating absolute volume and concentration among seven container ports in Southern African for 26 years (1985~2010)
Lee and Kwon (2014)	Measuring comparative competitiveness of ports in Northeast Asia and evaluating efficiency performance	Dynamic version of net shift approach (three sub-periods by three years)	Evaluating shift-share effects of 21 ports by three sub-periods and comparing the changed by a descriptive way
Jung (2014)	Analysing the economic relationship between the port of Busan and the regional economy	Comparative static version of shift-share approach (Three components)	Evaluating the change of six indicators of each industry by SIC and analysing factors between 1995 and 2012

In the new millennium, the application of the shift-share analysis in the port studies has several features. Firstly, the dynamic approach is preferred to the static one both because it can capture the trend of the changes over time and because it is not difficult to obtain the time-series data of port activities (Marti, 2006). Secondly, in terms of the research methodology, many research apply some port variables such as tonnage (in total cargo) and TEU (twenty feet unit), focusing on the level of competitiveness or concentration. However, in the recent study, some variables from regional accounts like the regional product began to be applied in order to investigate impacts of the port on its regional economy or the interaction port and its hinterland city (Jung, 2014). In other words, the economic impact of the ports can be measured by applying the dynamic approach, based on regional accounts in the context of a regional economy. Lastly, there are some challenging trials to attract the statistical results or the predicted outcome, by the way, by applying the dynamic approach with annual to five-year sub-period (Fowler, 2006, Notteboom, 2010).

In conclusion, the shift-share analysis can be an efficient methodology in the port studies due to the feature of showing both the longitudinal changes and the cross-regional differences at the same time. In fact, the approach is likely to be applied in various port studies; specifically, from the descriptive method to the statistical one in the methodological aspect, from cargo tonnage to the regional product of port-related activities in the aspect of the variable, from cargo flow or concentration/de-concentration to the economic impacts in the sight of the research objective

4.4 Econometric Analysis

4.4.1 Introduction

A dynamic approach of the shift-share analysis is quite useful to understand the economic changes but it has some limitations as mentioned in the previous section: specifically, it is a descriptive method with the little theoretic basis and requires broad information related to the causes of the economic changes. As such, this study needs to apply another economic methodology.

Since the quantitative methodology had been applied in the port study in the 1950s, the economic-based methodologies have been the key tool in analysing the impacts of ports (Heaver, 2006). Especially, the economic-based methodologies applied in the PISs are able to be categorized into three groups (Leunig, 2010, Draca et al., 2006)[67]. However, increasing interests are taken in the econometric analysis in the port studies as discussed in chapter 2; especially, to analyse the economic impacts of the ports (Shan et al., 2014). Furthermore, for the latest decade, some port studies apply the econometric methodology based on the growth model (Park and Seo, 2016). In addition, this study selects the econometric analysis[68] as the second main methodology based on the comparative assessment of the three approaches in Appendix 3.

As such, this study focuses on reviewing the exogenous growth model in order to understand the specified regression model. Since then, this study specifies how to apply the econometric model based on the consideration of the application in the ports studies.

4.4.2 Exogenous growth model

Various approach have been applied to explain the economic growth in the long run; for example, the Solow growth model (Solow, 1956) and the endogenous growth model (Romer, 1986, Romer, 1994). However, this study will focus on the Solow growth model and the Mankiew's augmented growth model, as considering the limitations of the endogenous growth models in the empirical analysis[69].

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[67] The demand-centric approaches: consumer surplus, social savings; the supply-centric approaches: IO analysis, multiplier effect; and the econometric approaches: growth accounting, TFP-based method, GMM method, the Olley-Pakes method, etc.

[68] Econometrics is to measure the economy based on economic theory, mathematical economics, and economic statistics and the econometric analysis is the methodology to measure the various variables quantitatively (Gujarati, 2009). The econometric analysis is applied in various research areas due to the characteristic of quantitative measurement and a number of the economic impact studies of port apply the econometric methodology.

[69] The endogenous growth model is evaluated to be superior to the exogenous approach in the point that growth factors are decided endogenously within the model; however, too many assumptions are required to model the relationship amongst too many unmeasurable factors (see Krugman, 2013).

4.4.2.1 The Solow growth model

Solow (1956) suggested the economic growth theory, based on the Harrod-Domar model of economic growth (H-D model), to solve the shortcoming which the H-D model studies the long-run issues with the short-run tools; especially, the assumption that the ratio of capital to labour is fixed. For this reason, he explained how an economy grows in the long-run while accepting the assumptions of the H-D model (Domar, 1946)[70] except that of 'fixed proportions'. And then, he approaches the growth of the economy in the long-run with four steps: how the growth of the economy can be assessed, what possible patterns the growth of economy may follow, how the growth pattern changes considering three kinds of the production function, and what happens as softening some assumptions like neutral technological change.

As the first step, using the H-D model, he defined what the growth of an economy is and how it can be evaluated. He understood the growth of the economy as the accumulation of capital, based on the assumption that the fraction of output (Y_t) is a constant s. So the stock of capital K_t is the accumulation of the net investment which is the increase rate of this capital stock dK/dt or $\dot{K}$. The basic identity at every instant of time is below:

$$\dot{K} = sY = sF(K, L) \quad \text{4-17)}$$

where, Y = output, K = capital, L = labour.

The production function shows constant returns to scale on the assumption there is no scarce non-augmentable resource like land. The labour force increases at a constant relative rate n as the growth of population is decided exogenously. In the absence of technological change, the constant n is Harrod's natural rate of growth. Thus:

$$L_t = L_0 e^{nt} \quad \text{4-18)}$$

By assuming that full employment is continuously maintained, total employment can be substituted with the available supply of labour. On the other hand, the above equation 4-18) can be interpreted as a supply curve of labour which means the exogenously growing labour force is offered for employment completely in-elastically. Thus:

$$\dot{K} = sY = sF(K, L_0 e^{nt}) \quad \text{4-19)}$$

[70]The assumptions in Domar's growth model: (a) there is a constant general price level; (b) no lags are present; (c) savings and investment refer to the income of the same period; (d) both are net, i.e., over and above depreciation; (e) depreciation is measured not in respect to historical costs, but to the cost of replacement of the depreciated asset by another one of the same productive capacity; (f) productive capacity of an asset or of the whole economy is a measurable concept.

Secondly, he showed how a capital accumulation path is decided in relation to the growth of the labour force, by introducing a new variable ($r = K/L$), the ratio of capital to labour, and differentiating it with respect to time. That is:

$$K = rL = rL_0 e^{nt}. \quad \text{4-20)}$$

$$\dot{K} = L_0 e^{nt}\dot{r} + nrL_0 e^{nt}. \quad \text{4-21)}$$

Substitute this in 4-19) and divide both variables in F by $L = L_0 e^{nt}$, based on the assumption of constant returns to scale:

$$(\dot{r} + nr)L_0 e^{nt} = sF(K, L_0 e^{nt}) = sL_0 e^{nt} F({}^{K}/_{L_0 e^{nt}}, 1). \quad \text{4-22)}$$

Dividing by the common factor ($L_0 e^{nt}$) and arranging the variable r in the right hand side, we get

$$\dot{r} = sF(r, 1) - nr. \quad \text{4-23)}$$

The equation 4-23) supply lots of information about both the equilibrium in the long-run and the rate of growth of capital stock. The function $F(r, 1)$ is the total product curve of capital per unit of labour and gives output per worker as a function of capital per labour. In addition, 'when $\dot{r} = 0$, the capital-labour ratio is a constant, and the capital stock must be expanding at the same rate as the labour force, namely n'(Solow, 1956, p. 69).

Thirdly, he showed how the pattern of the economic growth changes according to applying three kinds of production functions; H-D model with fixed proportions[71], the Cobb-Douglas function, and a whole family of constant-returns-to-scale production functions[72]. However, this study will review the Cobb-Douglas function in order to bridge to Mankiw's augmented model in the next sub-section. Applying the Cobb-Douglas production function in the equation 4-19), which can be transformed as below:

$$\dot{K} = sY = sK^{\alpha}(L_0 e^{nt})^{(1-\alpha)}. \quad \text{4-24)}$$

This can be integrated directly and the solution is:

$$K_t = \left[K_0^{(1-\alpha)} - \frac{s}{n}L_0^{(1-\alpha)} + \frac{s}{n}L_0^{(1-\alpha)}e^{nt}\right]^{1/(1-\alpha)} \quad \text{4-25)}$$

where, $K_0 =$ the initial capital stock.

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[71] This production function means the output is decided by the smaller unit in parentheses in the equation below:

$$Y = F(K, L) = \min({}^{K}/_{a}, {}^{L}/_{b}).$$

[72] This group are different from the Cobb-Douglas family in that output can be produced by only one factor in the equation below:

$$Y = F(K, L) = (aK^p + L^p)^{1/p}.$$

From the equation 35), as t becomes large, K_t grows basically like $\left(\frac{s}{n}\right)^{1/(1-\alpha)} L_0 e^{nt}$, namely at the same growth rate as the labour force. This can be interpreted that the equilibrium ratio were larger reasonably enough if the savings ratio would be higher or the increase rate of the labour supply would be lower.

As the last step, he presented five extensions: neutral technological change, the supply of labour, variable saving ratio, taxation, and variable population growth. In this part, the extension with regard to technological change will be reviewed (see others in Solow (1956, p.86-91)). The equation which the technological change is introduced in is transformed simply to multiply the production function by an increasing scale factor. That is:

$$Y = A_t F(K, L) \qquad \text{4-26)}$$

where, $A_t =$ the increasing scale factor of technological change.

Take $A_t = e^{gt}$ and the basic differential equation 34) is changed to

$$\dot{K} = s e^{gt} K^{\alpha} (L_0 e^{nt})^{(1-\alpha)} = s K^{\alpha} L_0^{(1-\alpha)} e^{(n-n\alpha+g)t}\ , \qquad \text{4-27)}$$

whose solution is

$$K_t = \left[K_0^{(1-\alpha)} - \frac{(1-\alpha)s}{(n-n\alpha+g)} L_0^{(1-\alpha)} + \frac{(1-\alpha)s}{(n-n\alpha+g)} L_0^{(1-\alpha)} e^{(n-n\alpha+g)t}\right]^{1/(1-\alpha)}. \qquad \text{4-28)}$$

In the long run, the capital stock increases at the relative rate $n + g/(1-\alpha)$, which is faster than n in the case of no technological change.

4.4.2.2 The augmented Solow growth model

In the Solow growth model, the productivity improvement was ‘mysteriously’ done by technology advancement, which is exogenous under this model. Even though Solow recognised that an economy grows without technological progress in the long-run, he derived the equation in the steady-state economy due to the easiness of mathematical representations (Solow, 1956). For this reason, many researchers found problems when applying the Solow growth model and tried to make a solution of the limitation of the model.

On the one hand, Romer (1986) and Lucas (1988) argued that the exogenous factor of technology improvement in the Solow model had not been fully explained. Thus they made the effort to include the technological change as the endogenous determinant of economic growth. In their model, not only the labour, the physical capital, but also things like human capital and innovation were considered as critical parts in the productivity improvement (Luo, 2016).

On the other hand, Mankiw et al. (1990, henceforth MRW) supplied the model in which human capital is added as an input in the same line of the Solow model based on the recognition that endogenous growth models can't explain that countries with similar technologies and rates of capital accumulation and population growth should converge in income per capita.

This study will review the debate among exogenous growth models and endogenous growth models focused on the augmented Solow model by MRW: the way to derive the MRW model, the specification for empirical analysis, and the advantages and disadvantages both in the theoretic aspect and in the empirical aspect, in order. Especially, even though the endogenous growth models are evaluated to be more realistic and deliver more policy implications (Ugur, 2016), it is naturally explained why a huge body of research implemented empirical analyses based on the Solow model and the MRW model.

4.4.2.2.1 The derivation of MRW model

MRW present the augmented Solow model which added human capital (H) to the Solow growth model in order to overcome several shortcomings of the original one: it regards to labour and capital as inputs but the rates of saving, population growth and technological progress as exogenous.

As the first step, MRW revisited the Solow growth model and then derived the augmented Solow growth model. Assuming a Cobb-Douglass production function and taking the technological change explicitly in the production function, they started from the production function like

$$Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha} \quad \text{4-29)}$$

where, Y=output, K = capital, L = labour, A=the level of technology, 0<α<1.

From the other assumption that L and A grows exogenously at rates n and g, the functions are given:

$$L_t = L_0 e^{nt} \quad \text{4-30)}$$

$$A_t = A_0 e^{gt} \quad \text{4-31)}$$

where, A_0 = the initial technology stock.

The model assumes that a constant fraction of output, s, is invested. Let's define k as the stock of capital per effective unit of labour, $k = K/AL$ (compared to $r = K/L$ in the Solow growth model), and y as the level of output per effective unit of labour, $y = Y/AL$. Substituting K with k in the equation 39) and differentiating with respect to time, the evolution of k is presented by

$$\dot{k}_t = sy_t - (n + g + \delta)k_t = s{k_t}^{\alpha} - (n + g + \delta)k_t \quad \text{4-32)}$$

where, δ = the ratio of depreciation (compared to $-n\alpha$ in Solow's model).

From this equation, MRW understood that k lied in the steady-state value k^* defined by

$$sk^{*\alpha} = (n + g + \delta)k^* \quad \text{4-33)}$$

$$k^* = [s/(n + g + \delta)]^{1/(1-\alpha)}. \quad \text{4-34)}$$

This equation can be interpreted that the steady-state capital-labour ratio is related positively to the ratio of saving and negatively to the ratio population growth.

In order to find steady-state income per capita, they substituted the equation 4-34) into the equation 4-29) and took natural logs. That is:

$$\ln[Y_t/L_t] = \ln A_0 + gt + \frac{\alpha}{(1-\alpha)}\ln(s) - \frac{\alpha}{(1-\alpha)}\ln(n + g + \delta). \quad \text{4-35)}$$

As the second step, MRW derived their augmented Solow growth model. They explicitly put human capital (H) in their Cobb–Douglas production function as a factor below:

$$Y_t = F(K_t, H_t, A_t, L_t) = {K_t}^{\alpha}{H_t}^{\beta}(A_tL_t)^{1-\alpha-\beta} \quad \text{4-36)}$$

where, α > 0, β > 0 and α + β < 1.

Then, it can be shown that each type of capital per effective labour ($k_t = K_t/A_t,\ h_t = H_t/A_tL_t$) evolves in a similar way in the Solow growth model.

$$\dot{k_t} = s_k y_t - (n + g + \delta)k_t \quad \text{4-37)}$$

$$\dot{h_t} = s_h y_t - (n + g + \delta)h_t \quad \text{4-38)}$$

where $s_k,\ s_h$ are the fraction of income invested in physical and human capital, respectively.

Since the equations show the growth pattern of physical capital and human capital, the steady-state $k^*\ and\ h^*$ in the long-run can be obtained by

$$k^* = \left[s_k^{(1-\beta)} s_h^{\beta}/(n + g + \delta)\right]^{1/(1-\alpha-\beta)} \quad \text{4-39)}$$

$$h^* = \left[s_k^{\alpha} s_h^{(1-\alpha)}/(n + g + \delta)\right]^{1/(1-\alpha-\beta)}. \quad \text{4-40)}$$

Finally, substituting these into the production function 4-29) and taking natural logs, the equation for output per capita is given by

$$\ln(Y_t/L_t) = \ln A_0 + gt - \left[\frac{(\alpha+\beta)}{(1-\alpha-\beta)}\right]\ln(n + g + \delta) + \left[\frac{\alpha}{(1-\alpha-\beta)}\right]\ln s_k + \left[\frac{\beta}{(1-\alpha-\beta)}\right]\ln s_h. \quad \text{4-41)}$$

The last equation means that economic growth depends on the initial level of technology (A_0) and its advancement (g) positively. However, the term ($n + g + \delta$) has a negative effect. In addition, it is positively clearly affected by the share of income invested in human capital (s_h) and in physical capital (s_k).

4.4.2.2.2 The specification of the augmented model

Mankiw et al. (1992) specified both models for empirical analysis and comparative assessment of the results, based on the equation 4-41). They focused on the relationship between the rate of real income growth and saving rates among countries, assuming g and δ are constant across countries. On the other hand, they regarded the A_0 term is decided per country, based on the resource endowment, climate, institutions, including the level of technology, and so on: they assumed

$$\ln A_0 = a + \varepsilon \qquad 4\text{-}42)$$

where, $a =$ a constant, $\varepsilon =$ a country-specific shock.

Thus, testable empirical functions for regression analysis, which are from the equation 4-35), can be derived from

$$\ln[Y_t/L_t] = a - \frac{\alpha}{(1-\alpha)}\ln(n+g+\delta) + \left[\frac{\alpha}{(1-\alpha-\beta)}\right]\ln s_k + \left[\frac{\beta}{(1-\alpha-\beta)}\right]\ln s_h + \varepsilon\ . \qquad 4\text{-}43)$$

Equation 4-43) is the basic empirical specification, based on the assumption that the rates of savings and population growth are independent of country-specific factor shifting the production function. This means that the term n and s are independent of the error term ε and is needed to apply ordinary least squares (OLS). As well, it is shown in Table 4-5what variables are applied and how variables are measured in empirical analysis with the equation 4-43). From the empirical analysis, they concluded that the augmented model improves the explanation ability of the Solow growth model.

Table 4-5 Empirical application of the augmented Solow growth model

	Concept	Measurement
Dependent variable	- Y/L: The real GDP per labour	- Real GDP ÷ the working-age population (15-64)
Independent variables	- n: the rate of population growth	- The average for the period 1960-1985
	- g: the rate of technical change	- $g + \delta$ is assumed to be 0.05.
	- $\delta(n\alpha)$: the rate of depreciation	
	- s_k: the ratio of income invested in physical capital	- Real investment(including government investment) ÷ real GDP
	- s_h: the ratio of income invested in human capital	- a proxy(SCHOOL): the enrolment rate in secondary school × the fraction of the working-age population that is of school age

Source: Mankiw et al. (1992).

4.4.2.3 Debates related to the MRW's application

4.4.2.3.1 Theoretical aspects

MRW's augmented model contributed to explaining the positive role of human capital in the frame of the Solow growth model. Especially, the implications, supported by various empirical analyses, are still evaluated as the direction for economic growth in the long-run. The main predictions of the MRW model can be summarized into four (Ugur, 2016). First of all, a 'steady-state growth path' is reached when output, capital and labour are all growing at the same rate. At the steady state, output per worker and capital per worker is constant. Secondly, shifting the trend rate of growth upward requires an increase in the labour supply and also a higher level of productivity of labour and capital. Thirdly, cross-country differences in the rate of technological change explain much of the variation in growth rates that we see. Lastly, catching-up and convergence: less developed countries catch up with the developed countries due to higher marginal rates of return on invested capital, and per capita income in less developed countries converge to the level in the developed countries.

On the other hand, it is clear that the MRW model has been the centre of the continuous debate. The first group of criticisms is related to the strong assumptions (Luo, 2016). The MRW model assumes full employment of labour, full utilization of capacity and no effective demand failures. In addition, it assumes that both technological progress and population growth are given exogenously. Secondly, it does not have a consideration of the investment function and the savings function: consequently, MRW overlooks the scope for investment-led growth (Ugur, 2016). Thirdly, the MRW model, including the Solow growth model, are criticised for lacking policy implications because economic growth is purely a function of inputs and technology is exogenous (Aghion and Howitt, 2007).

After the MRW model was published: especially turning in to the new millennium, a quite huge body of research has focused on the role of technological change in the long-run growth while addressing the so-called the 'Solow Paradox'.[73] One one hand, lots of economists who rooted in the endogenous growth theory have heavy interests in the importance of knowledge spill-overs from human capital: especially the highly skilled workers employed in the research and development (R&D) sector (Aghion and Howitt, 2007). On the other hand, many applied economists have a focus on the impact of information and communication technology (henceforth ICT) on productivity or economic growth (Waqar, 2015). According to Waqar (2015), most of the research has been implemented mainly via measuring the change of ICT capital stock based on various angles including different variables and proxies of ICT.

[73] R. Solow (1987) addressed, 'we could see computers everywhere but in productivity statistics.' This remark was to express the economic situation of the USA in 1980s that adopting computers in business was highly widespread but the productivity growth of the USA was slowdown from 1970s.

As a whole, the common implication of the two streams which are mentioned above is that fostering faster economic growth is not achieved by saving a large fraction of output but by investing a large portion of output in the R&D sector or the capital in the ICT industries (Ugur, 2016). On the other hand, Vu (2011) mentioned positive effects of ICT on the economic growth. First of all, ICT plays a role to foster innovation and technology diffusion as a general purpose technology (henceforth GPT): so-called 'spill-over effects' are focused on the similar impacts with R&D activities. Secondly, ICT contribute to improving the decision making procedure and efficiency of resource allocation. Lastly, the ICT revolution helps all economic actors to reduce production costs and foster demand and investment.

Despite various advantages which are addressed above, the endogenous growth theories or the innovation-based models have not overcome the criticisms which are raised in the light of the empirical analysis (Ugur, 2016). They have not supplied the implication, which MRW showed that the most countries are likely to converge roughly to the similar level of long-run growth rate, through the empirical analysis.

4.4.2.3.2 Empirical aspects

The specification which was applied in the empirical study by MRW is criticised by various research: especially, Temple (1999) and Islam (1995) argued that there are various detailed specification errors (Boutros, 2015). The first issue is parameter heterogeneity. Durlauf et al. (2001) discuss that while the Solow model may be relevant for individual countries, it is implausible that the estimated parameter regarding the savings rate of capital can be equally relevant for two very different countries. With regard to this issue, Boutros (2015) insists that the original model is both statistically and economically significant in the case that the purpose of the research is to make a general statement regarding the effect of the savings rate of capital on the growth of GDP per capita.

The second one is measurement error. This was a much larger issue almost three decades ago because it was difficult to get a data set as good as it is required for growth empirics. However, nowadays, it is not difficult to get many reliable resources which meet this demand and find good data any longer as much as it once was. For example, at the moment, the data related to the net enrolment ratio for secondary school can be gathered from all countries in the sample from a single source. On the other hand, there must be some errors in measuring macro variables such as GDP, but these are unavoidable and should not make us disregard the methodology (Boutros, 2015).

The third issue is the endogeneity. Human capital is clearly in the relationship with GDP per capita that both variables affect themselves mutually. For example, in an economic boom that increases GDP per capita, people may be able to afford better health care, increasing their human capital. However, several papers (Arnold et al., 2007, Kalaitzidakis and Korniotis, 2000) showed that this issue can be eliminated by using panel data with the lagged dependent variables as instrumental variables (Boutros, 2015). In addition, as time passes and more panel data is collected, the endogeneity can be better treated. As well, the papers above showed that treating the endogeneity does not significantly change the result in MRW's original analysis.

The last issue relates to two important rates: technological growth rate ($g = 0.02$), and capital depreciation rate ($\delta = 0.03$). On the one hand, in the theoretic sight, this issue is related to the criticism that the MRW model is based unrealistic assumption that technological progress is given at the ratio (g) exogenously. On the other hand, in the empirical sight, this issue is about the suitability to apply the same figure both among countries in very different economic situations and among time periods studied. With regard to this criticism, many papers supply the solution or the way that the error or the bias in empirical analysis can be treated appropriately (Luo, 2016, Boutros, 2015, Ram, 2007, Blundell and Bond, 1998). The first approach is to estimate two rates as a proxy by the growth ratio of total factor productivity (Luo, 2016). The second approach is to treat error by using the generalised moments method (henceforth GMM) while applying two rates same with the original paper by MRW. This method[74] is recommended to estimate the production function by Blundell and Bond (1998) and have been applied in the empirical studies (Guariglia and Poncet, 2008, Lo, 1997): even in some port studies (Shan et al., 2014). The last approach is to apply two rates just like the original paper (Knowles and Owen, 1995, Ram, 2007, Boutros, 2015). Boutros (2015) suggest that the results when applying two rates as a constant ($g + \delta = 0.05$) are slightly more significant than the ones when applying the technological progress rate ($g = 0.02$) as a constant and the capital depreciation rate varies among countries. These results can be interpreted that the technological change is captured in the error term as the fixed effect if it affects the economic growth as being reflected on the productivity of inputs and total factor productivity.

4.4.3 Applications in empirical analysis

Since MRW published the paper (1992), it is not difficult to look at the literature which apply the augmented Solow growth model with panel data such as Ding and Knight (2009): Islam (1995), Caselli et al. (1996), Bond et al. (2001), and Hoeffler (2002). Furthermore, lots of research derive various augmentations from Solow's model and Mankiw's one by introducing various variables (Dalgaard and Strulik, 2013): R&D (Nonneman and Vanhoudt, 1996), health and longevity (Knowles and Owen, 1995), the take-off (Temple and Wößmann, 2006), worker relocation (Ding and Knight, 2009) and so on.

[74] The residual term (u_{it}) consists of the error term ($\varepsilon_{i,t}$) and two more term which capture the temporal fixed effects (v_t)and the unobserved fixed effect of each region (μ_i) as below

$$u_{it} = v_t + \mu_i + \varepsilon_{i,t}.$$

Table 4-6 Variables (or proxy) in previous studies

Research	Dependent variable	Control variables	Additional variables
Solow (1956)	- Y/L: The real GDP per labour	- $(n+g+\delta)$: the sum of the rates of population growth, technical change, capital depreciation (assumed g, δ as 0.02, 0.03 respectively to all countries in the sample) - s_k: the ratio of income invested in physical capital	
Mankiw et al. (1992)	- Y/L: The real GDP per labour	- $(n+g+\delta)$: the sum of the rates of population growth, technical change, capital depreciation (assumed g, δ as 0.02, 0.03 respectively to all countries in the sample) - s_k: the ratio of income invested in physical capital	- s_h: the ratio of income invested in human capital
Knowles and Owen (1995)	- Y/L: The real GDP per labour	- $(n+g+\delta)$: the sum of the rates of population growth, technical change, capital depreciation (assumed g, δ as 0.02, 0.03 respectively to all countries in the sample) - s_k: the ratio of income invested in physical capital	- s_e: the ratio of income invested in 'educational capital' - s_x: the ratio of income invested in 'health capital'
Ram (2007)	- Y/L: The real GDP per working-age person	- $(n+g+\delta)$: the sum of the rates of population growth, technical change, capital depreciation (assumed g, δ as 0.02, 0.03 respectively to all countries in the sample) - s_k: the ratio of income invested in physical capital - s_h: the ratio of income invested in human capital	- ln(80 - life expectancy): the gap between 80 and the life expectancy of each country by the basis at birth in year 1985 - ln(IQ): a standard deviation of IQs for 81 countries
Bottasso et al. (2013)	- The regional employment	- The regional employment in the previous time - Motorways (km/pop) - Patents	- Throughput (000 of tons) - Passenger traffic (000 of pas)

Shan et al. (2014)	- The annual growth rate of per capita GDP	- Initial stock of per capita GDP - Human capital (a proxy: education level): (the number of secondary-school students enrolled ÷ population) ×100) - Government expenditure-to-GDP ratio - FDI-to-GDP ratio - Consumer price index - Road density: area of road ÷ area of the city	- Cargo throughput (million ton) - Container throughput (million TEU)
Boutros (2015)	- Y/L: The real GDP per labour	- $(n+g+\delta)$: compared various cases given $g = 0.02$ and $\delta = 0.03$ or $g = 0.02$ and δ varies - s_k: the ratio of income invested in physical capital - s_h: the ratio of income invested in human capital	
Luo (2016)	- $(Y_t - Y_{t-1})$: The real output change over the year - Lagged dependent variable: The last year's output	- $(n+g+\delta)$: g is estimated as a proxy with total factor productivity, δ is assumed as a constant but the specific figure is not presented - s_k: the ratio of income invested in physical capital - s_h: the ratio of income invested in human capital	
Park and Seo (2016)	- Regional real GDP per capita	- The previous year's value of real GDP per capita - $(n+g+\delta)$: g and δ are assumed as 0.05, n is estimated with the data - Physical capital(s_k): (regional real investment + real government expenditure) ÷ regional real GDP - Human capital(s_h): (a proxy) university graduates ÷ the number of economically active people	- Regional cargo throughput in ton - Container throughput in ton - The amount of regional port investment (including new construction) - Two dummy variables (if a region have an active port, if a region has an active container port)

Recently, there are several papers to assess if the MRW model still supplies the significant result both economically and statistically even in the 21st century or if the augmentation based on the MRW model can bring the statistically significant result (Ram, 2007, Boutros, 2015, Luo, 2016). Especially, Boutros (2015) and Luo (2016) insist that the results through the empirical analysis, which is implemented on the same condition but applying the data for the period 1990 to 2010 with the original paper by MRW, are still consistent.

It is not until the 2010s that a few papers (Bottasso et al., 2013, Bottasso et al., 2014, Shan et al., 2014, Park and Seo, 2016) in port studies apply the regression model, which is based on the augmented model, to analyse the economic impacts of ports on their cities or regions. It is much more surprising because there has been a huge body of research with economic base methodologies applied in the port studies since the 1960s. Even though it is not clear why the theory-based regression models begin to apply in port studies so lately, these literature show that they are a very powerful tool to understand the economic impact of ports on their cities or regions (Park and Seo, 2016).

Some research applies regression models, whether it is based on the economic theory or not, to analyse the regional economic impacts of ports (see Table 4-6). Bottasso et al. (2013) evaluate the economic impacts of port throughput, with three control variables, on local employment of 560 regions in 10 western EU countries over the period 2000–2006. They apply the linear GMM techniques which are robust to regional unobserved heterogeneity and to endogeneity of port activity. Bottasso et al. (2014) investigate economic effects of ports, by total production, on 621 regions of 13 Western EU countries over the period 1998–2009. On the other hand, Shan et al. (2014) investigate the economic impacts of 41 ports on their cities based on the revised regression function, by Guariglia and Poncet (2008), which has roots in the augmented Solow growth model. They introduce five variables as control ones and two variables from port activities as independent ones. Park and Seo (2016) analyse the economic impacts of ports, in applying the MRW model.

4.4.4 Model specification

This study will basically follow the specification of Park and Seo (2016), which follows the specification of Mankiw et al. (1992) but is modified to adopt a two-way error component that accounts for a varying intercept over both time and region. However, for the more adequate model on this study's objectives, some variables will be adjusted: for example, road density as control variable, so that the baseline is given by

$$\ln y_{it} = \beta_0 + \beta_1 \ln(n_{it} + g + \delta) + \beta_2 \ln s_{k,it} + \beta_3 \ln s_{h,it} + \beta_4 \ln y_{it-1} + \beta_5 \ln rd_{it} + \gamma \ln X_{it} + u_{it} \quad \text{4-44)}$$

where $\beta_0, \beta_1, \beta_2, \beta_3, \beta_{4,} \gamma$ = coefficients, X_{it} = port related variable, u_{it} = the region-specific error term.

This study assumes the residual term $u_{it} = v_t + \mu_i + \varepsilon_{i,t}$, which is adopted in the literature by Shan et al. (2014) where v_t is a time component of capturing temporal fixed effects, μ_i is the unobserved fixed effect for region i and $\varepsilon_{i,t}$ is the idiosyncratic error term.

Control variables are selected by the augmented Solow model and measured as shown in Table 4-7. First of all, as both control variable and the dependent one, growths are measured by regional real GVA per worker based on log approximation. Secondly, the effective rate of capital depreciation is approximately calculated by the sum of population growth rate and 0.05 ($g + \delta$), as recommended by Mankiw et al. (1992) and applied by various authors (Ram, 2007, Boutros, 2015, Luo, 2016). Thirdly, the share of income invested in physical capital (s_k) is measured as the amount of regional real investment (including real government expenditure) divided by regional real GVA. Fourthly, the share of income invested in human capital (s_h), as Park and Seo (2016) applied, is represented by a fraction of university graduates over the number of economically active people who are either employed or actively seeking jobs. Fifthly, the previous year's value of real GVA per worker (y_{t-1}) is also added to control for convergence in economic growth. Lastly, road density (denoted by rd), as Shan et al. (2014) applied, will be calculated by the road area (in ten thousand square meters) per worker, in order to control for the level of development of the transport infrastructure.

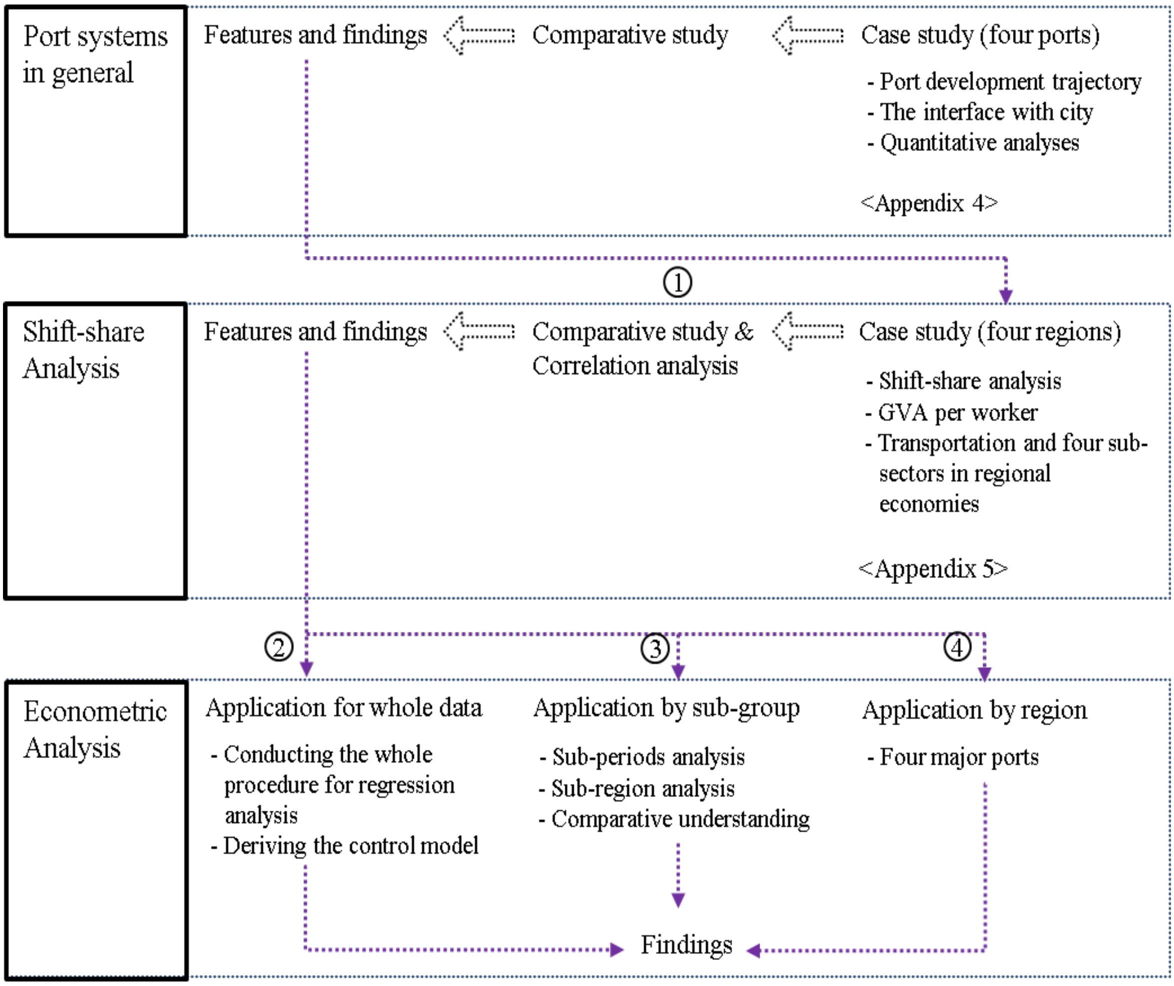
Table 4-7 Variables for empirical analysis in this study

	Concept	Measurement
Dependent variable	- y_i: The real GVA per worker	- Real GVA ÷ the population in a region
Control variables	- $(n_i + g + \delta)$: the sum of the rates of population growth, technical change, capital depreciation	- The average for the period 1985-2015 - $g + \delta$ is assumed to be 0.05, which is applied by Mankiw et al. (1992), Knowles and Owen (1995), Ram (2007), Boutros (2015), Luo (2016), etc.
	- $s_{k,i}$: the ratio of income invested in physical capital	- Real investment (including government expenditure) ÷ real GDP
	- $s_{h,i}$: the ratio of income invested in human capital	- (a proxy): university graduates ÷ the number of economically active people
	- rd_{it}: Road density	- (a proxy): area of road ÷ employment
Port-related variables	- Cargo throughput in tonnes	- Annual data
	- Container throughput in TEUs	- Annual data

4.5 Summary

This chapter discusses why, for what and how the empirical analysis is conducted. As well, this study reviews the shift-share analysis and the econometric analysis. In conclusion, what is discussed in this chapter can be shown in the sight of the research procedure with regard to the empirical analysis, as shown in Figure 4-1. As the first step, the contextual understanding of port systems is conducted with two steps: a case study of the four individual ports shown in Appendix 2 and the comparative study discussed in chapter 3. The key findings supply the implications for the shift-share analysis of the individual four regions. As the second step, the shift-share analysis is implemented. This analysis is divided into two steps just of the analysis by a port and the comparative study for the four port regions. The key findings derived through the comparative study will suggest some significant implication by itself and for the econometric analysis. As the last step, this study implements the application of the econometric analysis at the various levels: application for the whole data, application by sub-group, and application by region. The results from the different applications will supply quite meaningful information and imply some suggestions for the port studies and the port policies.

Figure 4-1 Flow chart of the empirical analysis in this study



Focused on the relationship between the methodologies, Figure 4-1 shows the four denoted different lines. The line denoted 1 implies that the features and findings by the contextual understanding are playing a role as the background for implementing case studies of four port regions and the criteria for interpreting the results of the case studies and comparative analysis.

On the other hand, the results of the shift-share analysis, which are both background and criteria for the econometric analyses, have three different relationship with the different applications of the econometric analysis. Firstly, with regard to the line denoted 2, the results of the shift-share analysis will show the features of transportation in 16 regional economies in the sight of the industrial structures; especially, in the sight of the magnitude and the proportion of the GVA per worker of transportation and the four sub-sectors in transportation. As a result, the results will supply key information about whether the whole panel data are consistent with the homogeneous or weak heterogeneous assumption or not. If the 16 regional economies have the heterogeneity, this study needs to reflect the feature of violating the assumption for the econometric analysis (Baltagi, 2008). In conclusion, the results will supply a background for interpreting the results of the econometric analysis.

Secondly, with respect to the line denoted 3, the results of the shift-share analysis answer the question why this study introduces the sub-period analyses and the sub-region analyses in the econometric analysis. In other words, the strongly heterogeneous structures in 16 regional economies; especially, 11 port-regional economies, imply the high risk of estimating biased statistical relationship between the port-related variable and the growth of the regional economies. Even though the econometric analysis for the panel data considers the systemic difference in the values of panels between individuals or regions, the approach is fundamentally based on the rationale that the statistical relationship is the same or such similar as a single coefficient can be estimated (Hsiao, 2007). For this reason, the sub-group analyses can be a practical approach to mitigate the heterogeneity by splitting the quite different values into several groups and to improve the goodness of fit and the power of the models in the econometric analyses.

Lastly, in the case of the line denoted 4, the results of the shift-share analysis are related to the application of the econometric analysis by region differently from the two previous cases. In chapter 9, this study is focusing on directly connecting the two methodologies of the shift-share analysis and the econometric analysis. In order to do so, this study conducts the econometric analysis by region as introducing additional variable of *CE* and *IM* generated by the shift-share analysis. As a result, this study will show if and in what case the additional variables of *CE* and *IM* are statistically significant at the confidence level of 90%. In addition, the results will adversely supply the statistical information for the results of the shift-share.

In conclusion, these discrete but related methodologies will propose abundant information with regard to the economic contribution of the port-related activities as considering the changes in surroundings such as the intensification of the functional integration and the spatial enlargement.

Chapter 5 Shift-share Analysis

5.1 Introduction

The shift-share analysis is such a helpful tool to decompose the economic changes among industries in a region or among regions of an industry at the same time, compared to the changes in the national economy as a benchmark economy. For this reason, this methodology is applied in a huge body of empirical studies in various disciplines such as regional economics, geography and regional science (Nazara and Hewings, 2004)

This approach is generally applied to compare the changes between a pair or several pairs of two specific times (Haynes and Parajuli, 2014). This method was applied in the several port research as shown in chapter 4 (Jung, 2014, Fraser and Notteboom, 2012, Notteboom, 2011). This approach has the advantage in the point to present the magnitude of the change between various time periods according to the research objective. However, this methodology has the drawback not to provide any information with regard to the trends and the factors of the changes over time.

For making up for the weaknesses, this study tries to gather further detailed information by applying two new approaches. On one hand, this study examines the presence of trends over time by analysing the annual changes in the GVA per worker while most studies focus on what the changes are between two specific times. On the other hand, this study repeats the application of the shift-share analysis for the disaggregated data of the four sub-sectors in transportation to show the factors and the regional characteristics with regard to the changes in the GVA per worker of transportation in the four major port regions.

This research approaches the descriptive analysis of the economic impacts of four major container ports with three steps as follows. First of all, this research briefly overviews the changes in the GVA per worker in the various aspects: specifically, in the Korean economy, in transportation of the national economy, the regional distribution and the four sub-sectoral compositions of transportation, and the status of transportation in the 16 regions. For this analysis, this study uses the data from regional accounts but not the data from the national accounts. Secondly, this research investigates the changes in the GVA per worker of transportation in the four major port regions with the comparative analysis based on the results from the individual application of the shift-share analysis as shown in Appendix 4 Shift-share Analysis. Especially, the application of the shift-share analysis for the four sub-sectors in transportation suggests some significant results to understand the changes in transportation. In the last section, this study briefly compresses the key findings from the application of the shift-share analysis.

5.2 Major changes in transportation

In this section, this study examines what growth pattern transportation at the national and regional level follows over time during the studied period through applying the top-down approach. This study starts to overview the changes in the national economy and understand the changes in the status of transportation. Then, this study examines which region and which sector contribute to the growth of the national transportation. Lastly, this study discusses the changes in the amount and the status of the transportation in a regional economy by examining the annual changes in the GVA per worker.

5.2.1 Overview of the Korean economy (1990~2015)

The GVA per worker in the national economy has increased by 29 million KRW from 22 million KRW in 1990 to 51 million KRW in 2015, as shown in Figure 5-1. It has increased by 3.42% of the average annual growth rate for 25 years from 1990 to 2015 and has experienced the positive annual growth except for two years: 1998 and 2009. Meanwhile, in the sight of the trend, the GVA per worker in the national economy clearly shows that the annual growth rate is likely to drop over time and be stagnant by a decade approximately; 4.89% in the 1990s, 3.10% in the 2000s, and 1.19% in 2010s. This decreasing trend by a decade is far steeper than the pattern of the GVA in the national economy; 6.55% in the 1990s, 4.33% in 2000, and 2.92% in the 2010s.

In the sight of a sectoral proportion, the Korean economy has experienced the rapid structural changes and such a huge discrepancy in the growth rate among 16 industries in SIC. The list of which industry makes a greater GVA per worker in 2015 has changed slightly compared to the one in 1990.[75] In detail, four sections; Manufacturing, Wholesales and retail trade, Real estate activities, and Public administration, continue to be on the list in 2015. However, Construction and education, which was on the list in 1990, is out of the list in 2015 but Professional activities and Financial and insurance activities, which were not on the list in 1990, are on in 2015. What is interesting with regard to this study is that the proportion of Manufacturing in the national economy has increased from 21.12 % in 1990 to 31.72% in 2015. It is why the growth of transportation is likely to be much more dependent on Manufacturing than other service industries. As a sector of the national economy, transportation has increased differently over time in the growth rate as shown in Figure 5-2; namely, transportation increased faster in the 1990s and slower in 2000s than the national economy. As a result, the status

[75] The name and the proportion of top six industries by GVA per worker
- Lists in 1990: Manufacturing(21.12%), Whole sales and retail trade(11.71%), Construction(11.19%), Public administration(8.42%), Education(8.06%), and Real estate activities(7.9%).
- Lists in 2015: Manufacturing(31.33%), Whole sages and retail trade(9.34%), Real estate activities(7.46%), Professional activities(7.17%), Public administration(6.8%), and Financial and insurance activities(6.68%)

Figure 5-1 GVA per worker in the national economy

(Unit: thousand KRW)

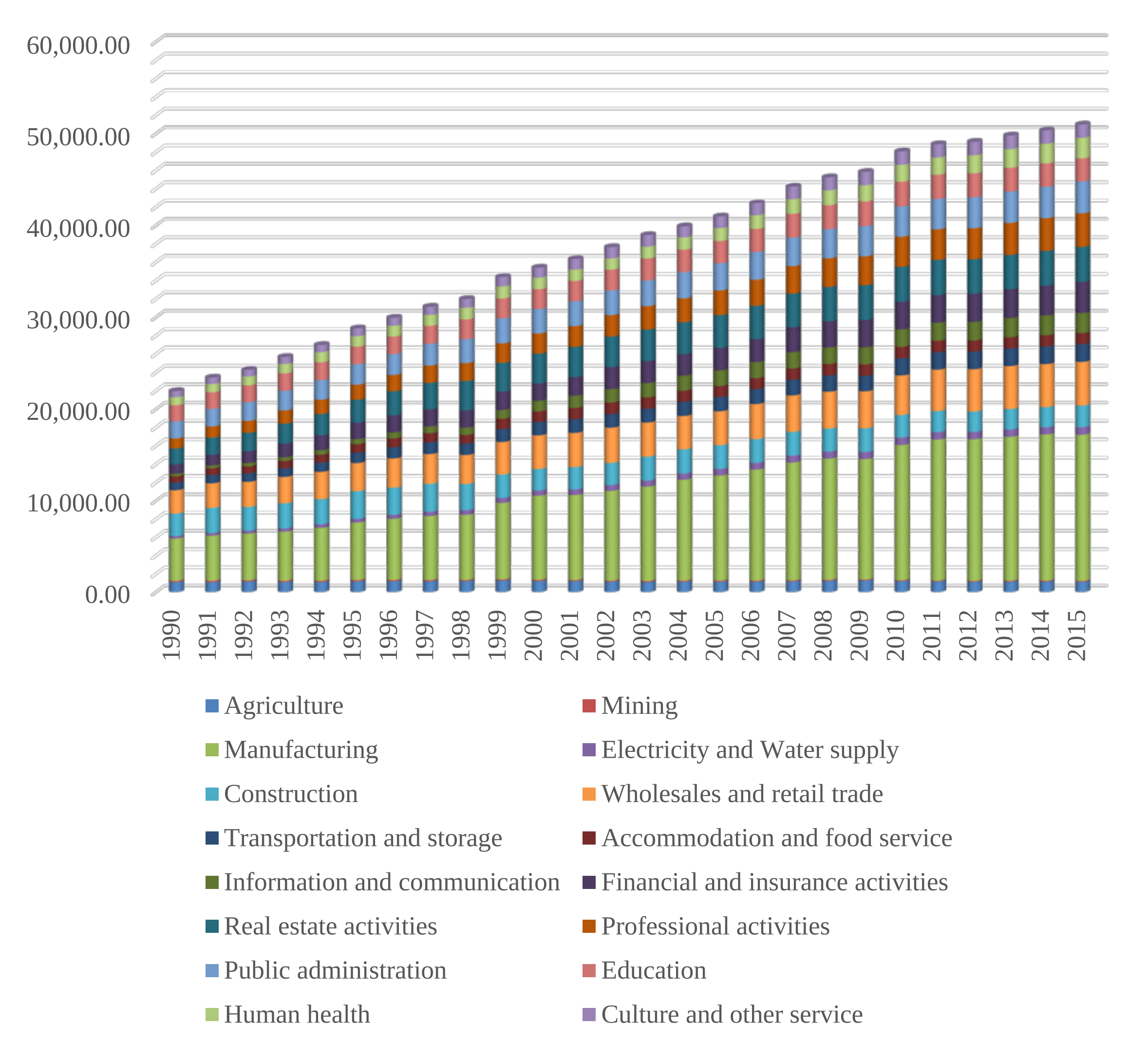


Figure 5-2 Proportion of transportation in the national economy

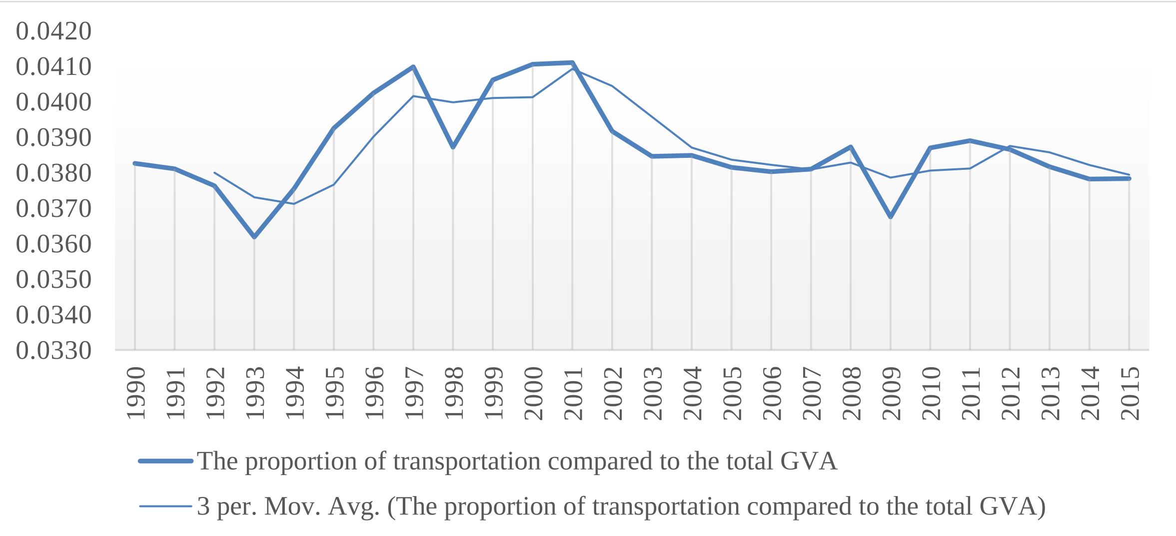


Figure 5-3 Regional GVA per worker in Metropolitan cities

(Unit: thousand KRW)

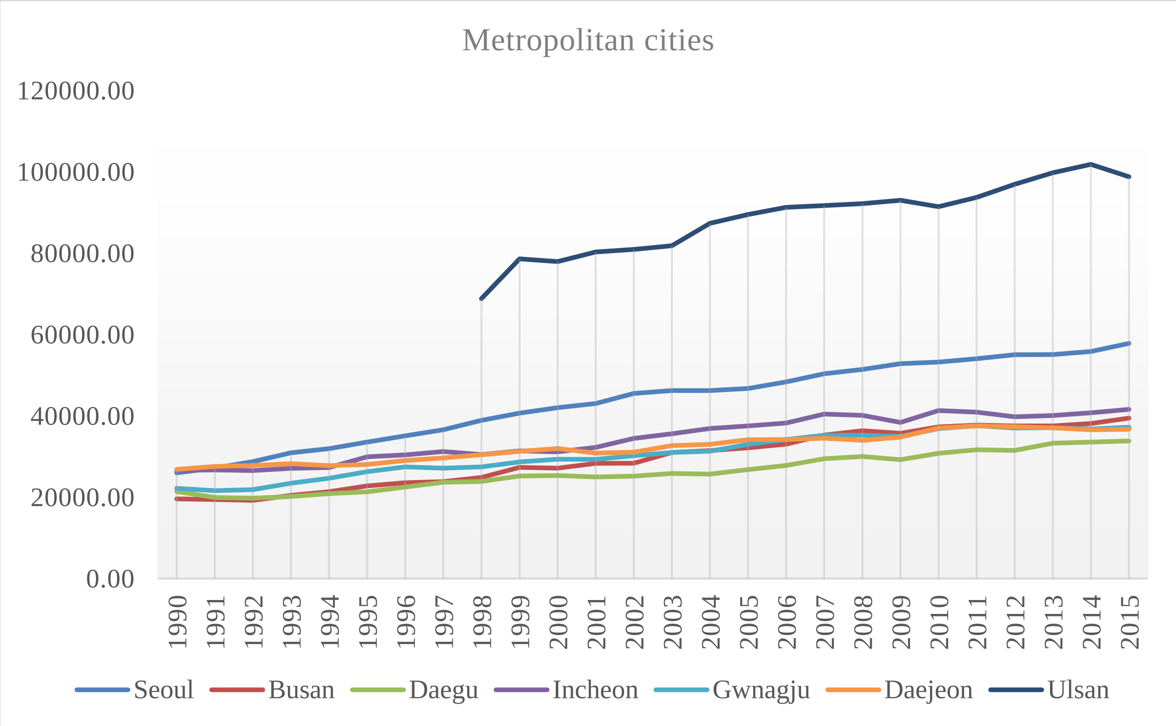
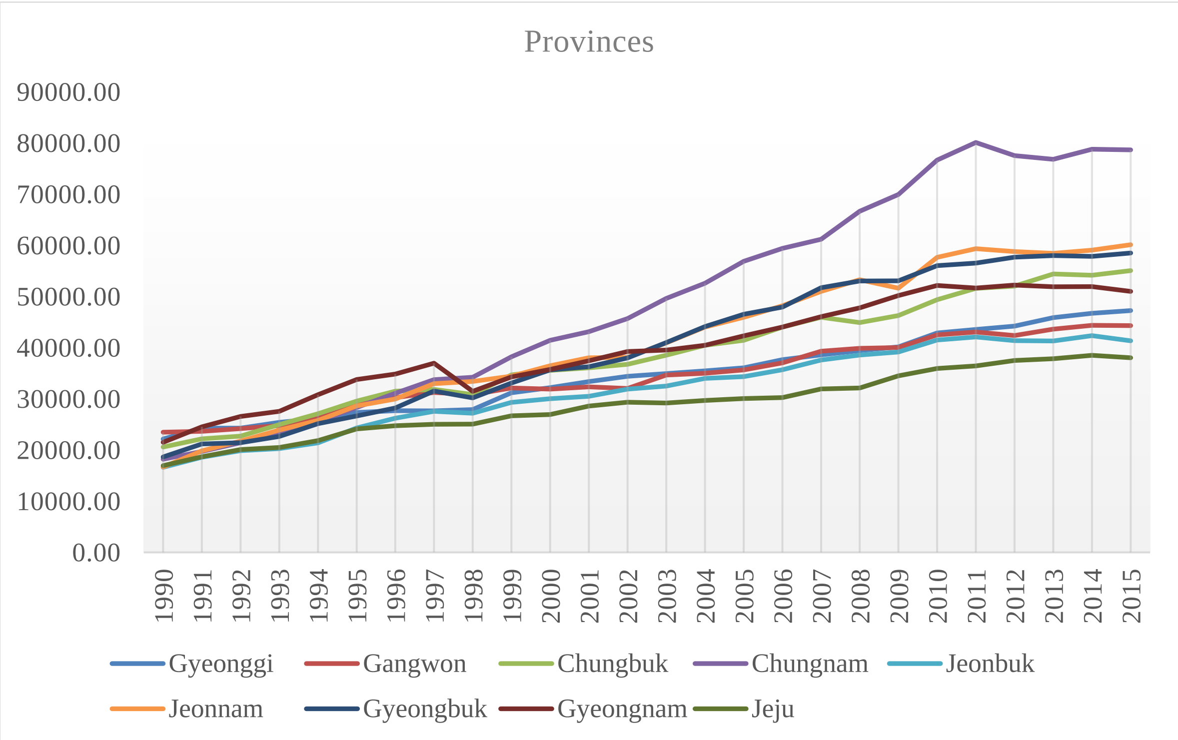


Figure 5-4 Regional GVA per worker in Metropolitan cities

(Unit: thousand KRW)



of transportation in the national economy, which had been 3.8% in 1990, continued to increase rapidly to 4.1% by 2001, which is the culmination for the last three decades, but returned to 3.8% in 2015 after continuous decrease since 2002.

Lastly, in the aspect of the regional proportion, the discrepancy in the GVA per worker between 16 regions, which consist of seven metropolitan cities and nine provinces, has been getting greater in amount, as shown in Figure 5-3 and Figure 5-4. The regional GVA per worker both in metropolitan cities and in provinces were around 20 million KRW in 1990 but scatters from 30 million KRW to 100 million KRW in 2015. Meanwhile, the GVA per worker in metropolitan cities have increased less than the one in provinces. The metropolitan cities except for Ulsan and Seoul have the GVA per worker of 30 million KRW to 40 million KRW in 2015. On the contrary, most provinces made the GVA per worker between 40 million KRW and 60 million KRW in 2015. It can be understood that 16 regional economies have been differentiated over time in the sight of the sectoral structure and the growth engine.

5.2.2 Transportation in the national economy

Economic variables of a sector in SIC is calculated by aggregating the variables in 16 regions and of four sub-sectors in transportation (BOK, 2016). For this reason, this study understands the changes in the national transportation by looking at the ones in the regional proportion and the sectoral one.

In the sight of the regional proportion, the 16 regions have such a different status in the transportation as shown in Figure 5-5 and Figure 5-6. The 16 regions can be classified into three groups by the criteria of the GVA in transportation. As the leading group whose regional proportion is above 10%, Seoul, Busan, Gyeonggi, and Incheon accounted for 59.77% of the whole GVA made in transportation in 1990 and account for 63.56% in 2015. However, the regional GVA of transportation has shown quite different patterns. The GVA of transportation in Seoul continues to decrease so that its proportion shrank by 16.10% points from 34.84% in 1990 to 18.74% in 2015. To the contrary, Incheon and Gyeonggi increased rapidly their proportions by 10.85% points and 9.60% points from 5.72% and 6.90% in 1990 to 16.57% and 18.01% in 2015 respectively. In the case of Busan, the GVA in transportation experienced up and down dramatically in the proportion so its ratio increased by 3.25% points from 12.31% in 1990 to 15.56% in 2001 but decreased by 5.31% to 10.25% in 2015. As the second group, Gyeongnam, Jeonnam, Gyeongbuk and Chungnam in provinces show the trend to fluctuate between 4 and 5%; meanwhile, Gyeongnam increased the proportion rapidly from almost 6% in 1990 to near 10% in 1997 but has kept around 5% since Ulsan separated from Gyeongnam in 1998. As the last group, Daegu, Gwangju, and Daejeon in metropolitan cities which do not have seaports and Gangwon, Chungbuk, Jeonbuk, and Jeju in provinces have kept the regional proportion under 3% in 2015. What is interesting is that Daegu, Gwangju, and Daejeon in metropolitan cities

Figure 5-5 Regional proportion of transportation in the national transportation in Metropolitan cities

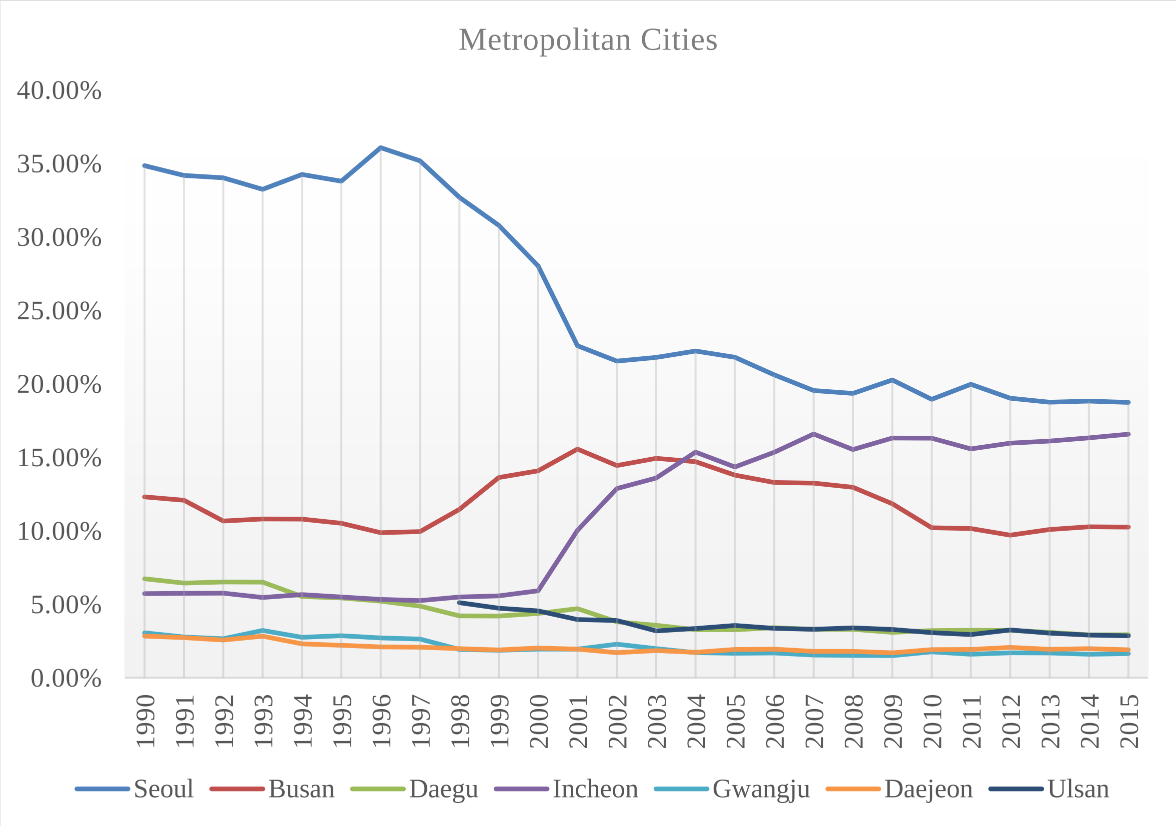


Figure 5-6 Regional proportion of transportation in the national transportation in Provinces

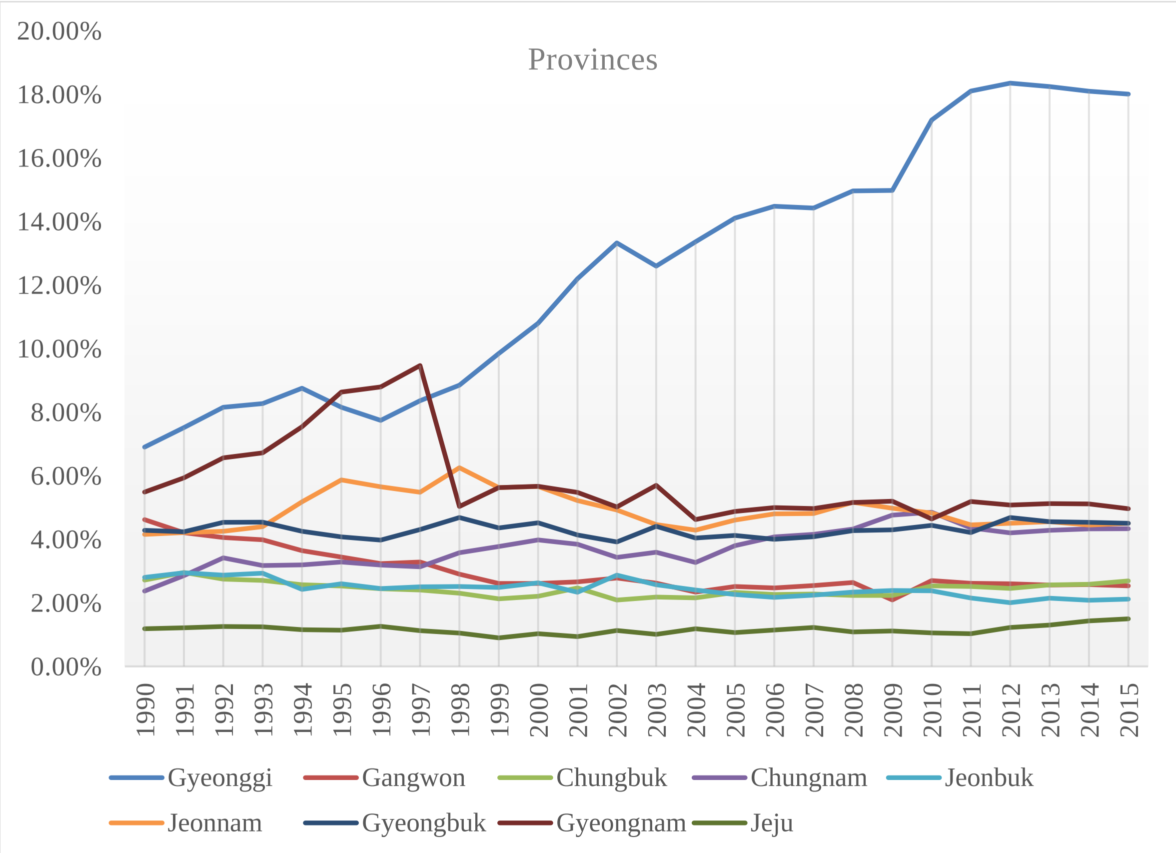


Figure 5-7 GVA per worker of four sub-sections in transportation

(Unit: thousand KRW)

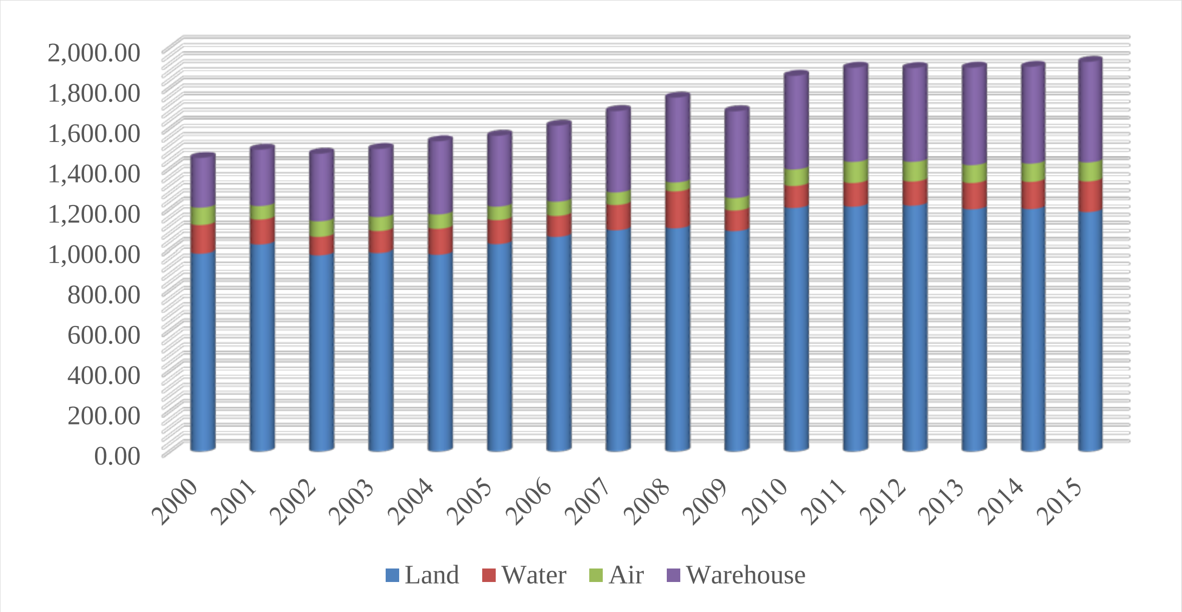


Figure 5-8 Growth rate of GVA per worker of four sub-sections in transportation

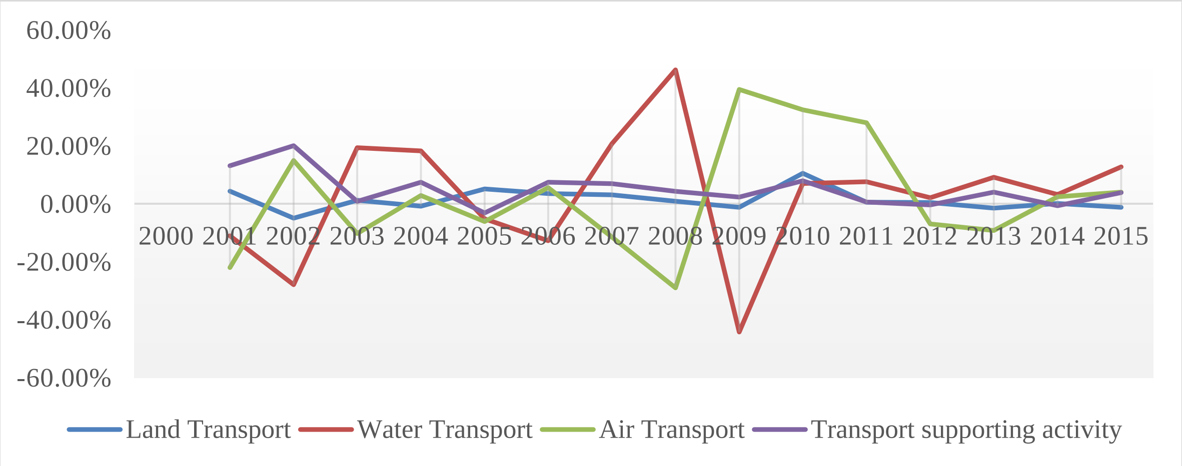
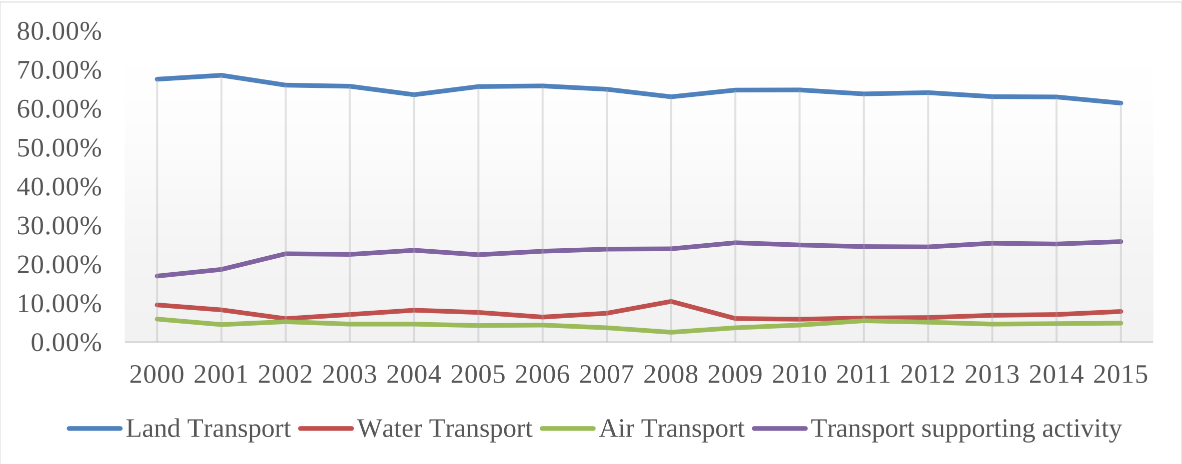


Figure 5-9 Proportion of GVA per worker of four sub-sections in transportation



and Gangwon, Chungbuk and Jeonbuk in provinces are inland regions which do not have seaports or coastal regions which do not have any container dedicated facilities. It can be considered that the presence of seaports is not everything to explain the regional discrepancy in transportation but must be something to affect it significantly.

On the other hand, in the sight of four sub-sectors in transportation, the changes of GVA per worker in transportation are quite useful to understand the changes in transportation better. The trends that four sub-sectors have stepped in the sight of the GVA per worker are shown in Figure 5-7, Figure 5-8 and Figure 5-9.[76] The GVA per worker in transportation in Figure 5-7, which is aggregated with four sub-sectors; land transport, water transport, air transport and transport supporting activities, has increased continuously except for 2009. The amount of the GVA per worker in transportation is almost 1,928 thousand KRW in 2015 which are disaggregated to 981.81 thousand KRW of land transport, 138.91 thousand KRW of water transport, 86.05 thousand KRW of air transport, and 246.67 thousand KRW of transport supporting activities in 2000. As well, the amount consists of 1,184.73 thousand KRW, 152.15 thousand KRW, 93.92 thousand KRW, 498.16 thousand KRW in 2015 respectively. In the sight of the annual growth rate in Figure 5-8, the four sub-sectors have recorded respectively by 1.26%, 0.61%, 0.59%, and 4.80%; namely, transport supporting activities has grown far faster than others. In the sight of the sectoral proportion in Figure 5-9, land transport accounts for about 60% and transport supporting activities takes charge of about 26%. Water transport and air transport take charge of 8% and 5% respectively.

From the results above, the four sub-sectors can be understood to be in some patterns as following. Firstly, a node which means the activities to connect transport modes; especially, activities in the port and the distribution centres including warehousing, grows faster than three modes of transport. Secondly, water transport and air transport are fluctuating very unstable but land transport and transport supporting activities are increasing continuously. It may be because water transport and air transport in South Korea depend mainly on international cargos and passengers. Lastly, the growth rate of the four sub-sectors is likely to get lower.

5.2.3 Transportation in the regional economies

At the sight of a sector in a regional economy, transportation has different meanings in a regional economy as shown in Figure 5-10, Figure 5-11, Figure 5-12 and Figure 5-13. The four figures show how big GVA per worker transportation has created and how big proportion transportation has accounted for in a regional economy.

[76] The raw data with regard to the four sub-sectors in transportation since 2000 are applied due to the constraint of gathering the consistent data.

Figure 5-10 Regional GVA per worker of transportation in Metropolitan cities

(Unit: thousand KRW)

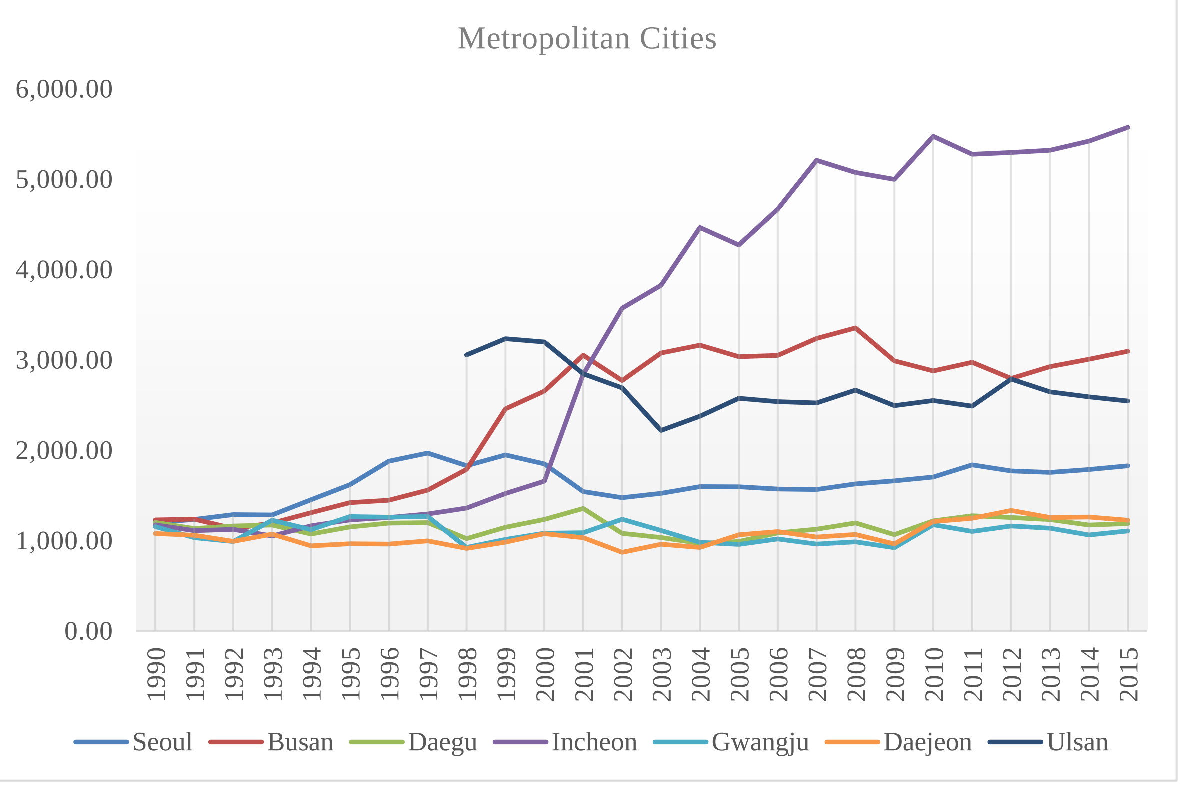


Figure 5-11 Regional GVA per worker of transportation in Provinces

(Unit: thousand KRW)

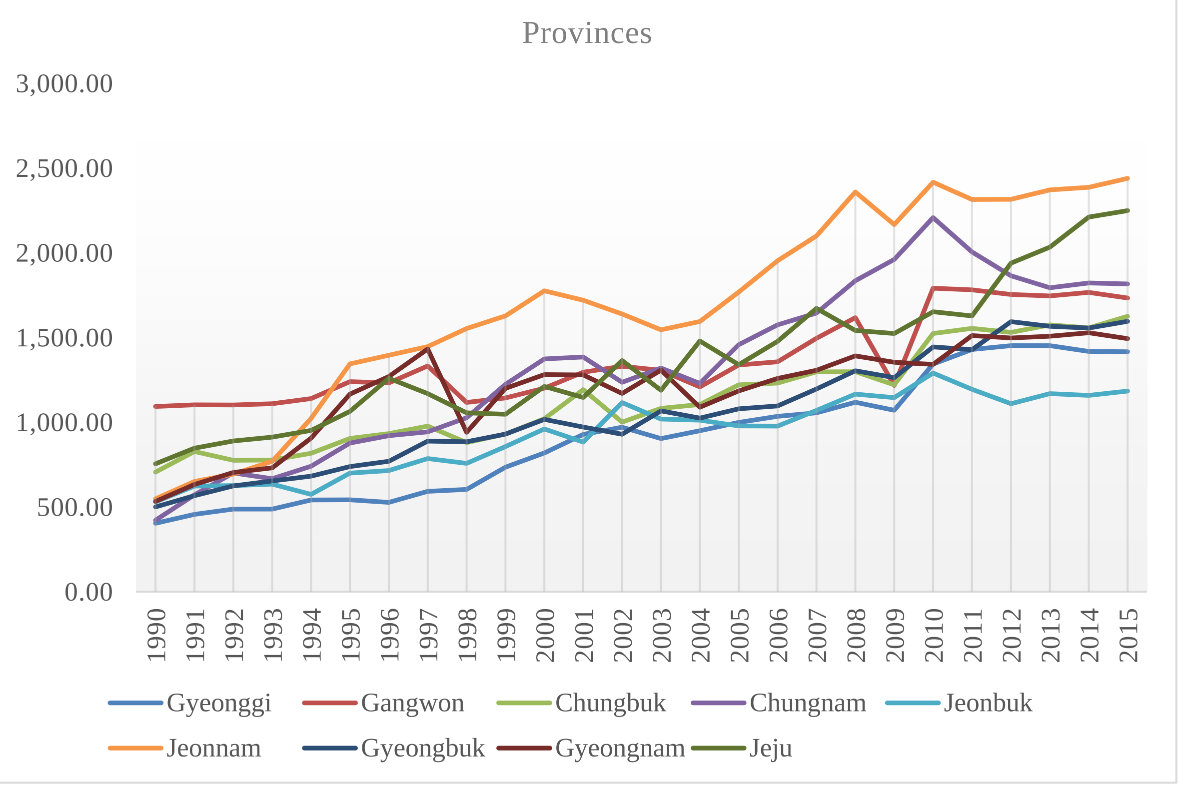


Figure 5-12 Proportion of transportation in a regional economy in Metropolitan cities

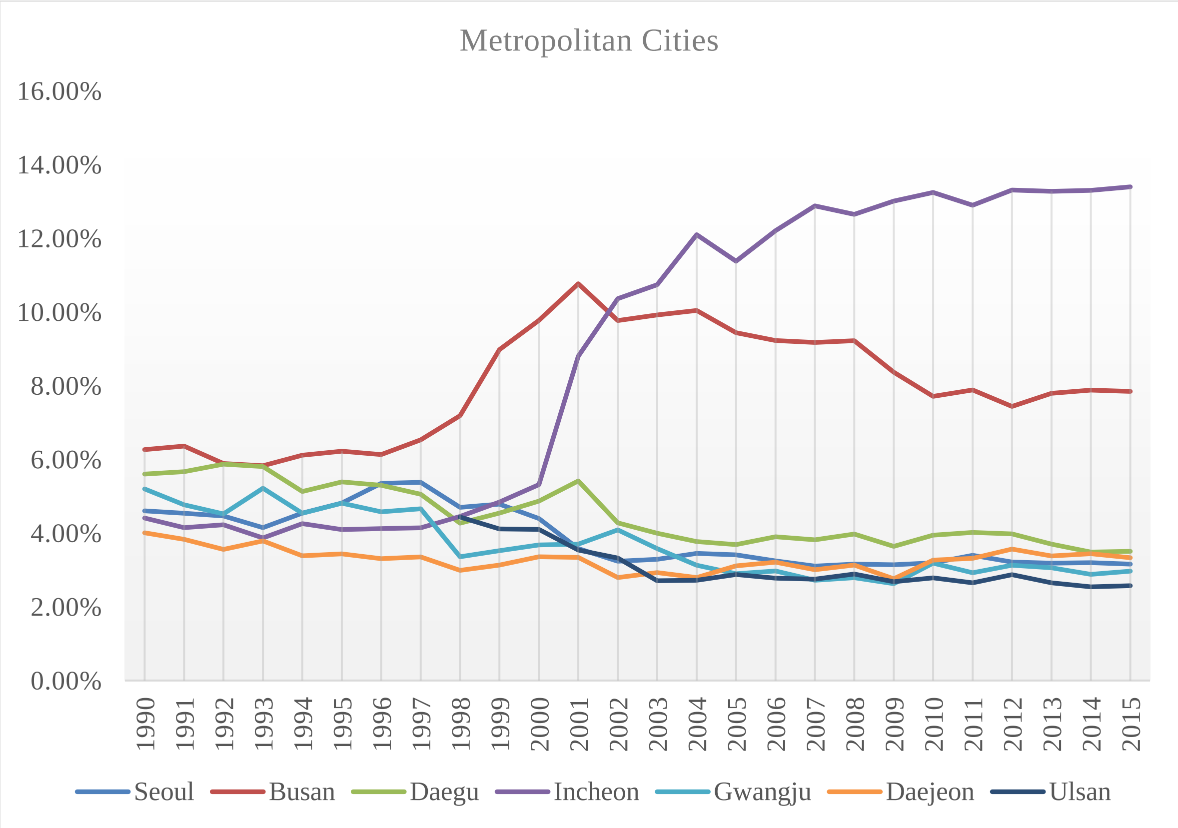
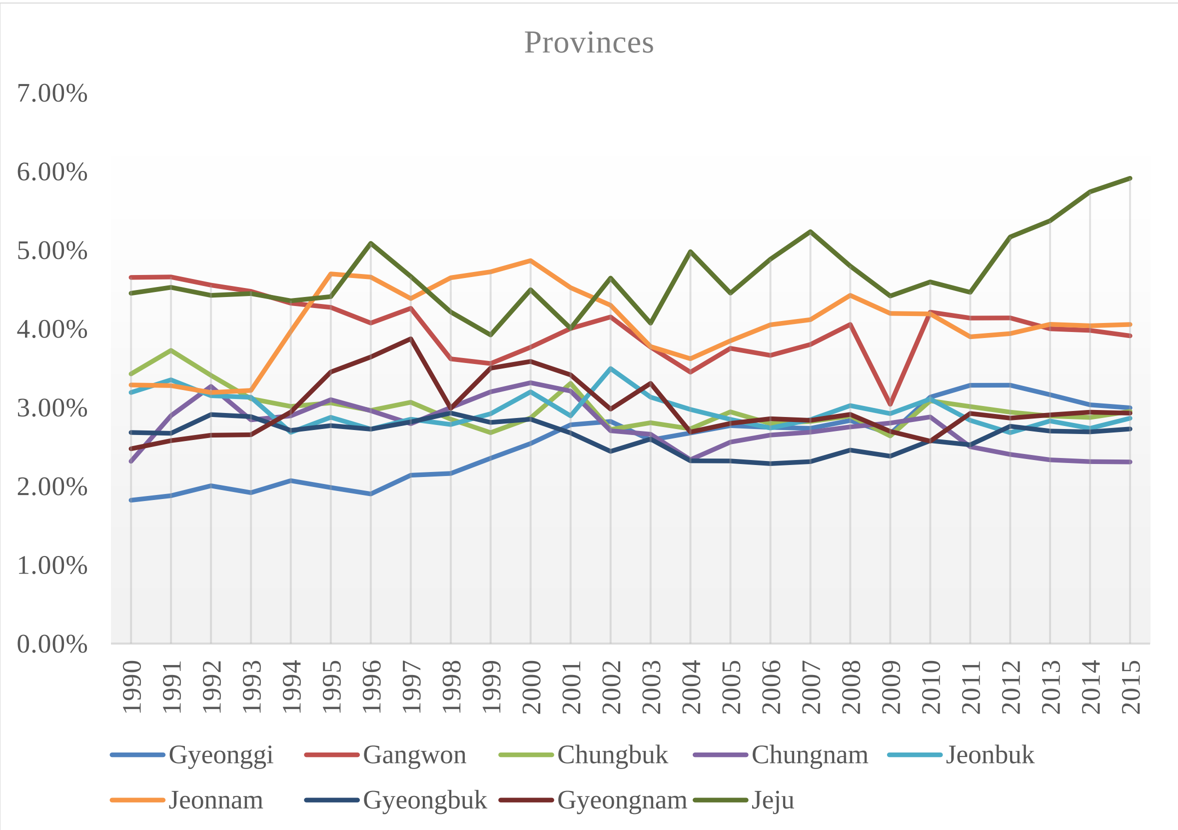


Figure 5-13 Proportion of transportation in a regional economy in Provinces



In the point of the amount of the GVA per worker, Incheon, Busan and Ulsan, as shown in Figure 5-10 and Figure 5-11, are superior to others in metropolitan cities and Jeonnam and Jeju are much higher than others in provinces. Considered that the GVA per worker in transportation is 1,940 thousand KRW in 2015, transportation contributes to the growth of a regional economy in Incheon, Busan, Ulsan, Jeonnam and Jeju. Incheon has recorded an explosive increase in transportation since 2001 so that it has been the region that transportation makes the greatest amount in the GVA per worker, which is 5,300 thousand KRW in 2015. Busan experienced that transportation increased rapidly during the late 1990s but repeated up and down since 2000. In the case of Ulsan, the GVA per worker in transportation dwindled steeply for several years after separation in 1998 and has been recovering year by year. Transportation in Jeonnam and Jeju also continue to grow, even though decreased contemporarily, so that makes the GVA per worker bigger than 2,000 thousand KRW in 2015. Transportation in other regions made GVA per worker less than one in transportation in the national economy.

In the sight of the sector proportion in a regional economy, Incheon, Busan, Jeju, and Jeonnam, as shown in Figure 5-12 and Figure 5-13 are located in the top place in the metropolitan cities and in the provinces respectively. Transportation in the four regions in 2015 has much bigger proportions in the regional economy greater such as 13.39%, 7.84%, 5.91% and 4.06% compared to the one of transportation in the national economy, which is 3.8% in 2015. What is interesting is that Ulsan is out on the top five regions in the sight of the proportion but Gangwon is in. The proportion of transportation in Ulsan, in which the amount of the GVA per worker in transportation is considerably high, is below the proportion of transportation in the national economy. Meanwhile, what is clear is that the proportion of transportation in Incheon and Busan are quite high. Compared to the proportion in other regions, the one in Incheon is almost five times as high as the one in Seoul, Daegu, Gyeonggi and Chungbuk which do not have any coastal area. Meanwhile, the proportion of transportation in Busan is almost two and a half times as high as the regions.

5.2.4 Summary

This study reviews the changes of the GVA per worker in transportation in the national economy and in the 16 regional economies. However, it is not clear what differences are in the 16 regional transportation and what significant meaning the results imply. For a better understanding of the results, the 16 regions are arranged on the two-way scattered with the amount of the GVA per worker in transportation and the proportion of transportation in a regional economy. As shown in Figure 5-14, the relationship between the amount and the proportion are analysed in 1990, 2000, and 2015. At a glance, it is clear that the status of transportation in a regional economy has differentiated by region over time and that the 16 regions can be classified by the amount and the proportion in 2015.

Figure 5-14 Changes in GVA per worker and proportion of a regional transportation over time

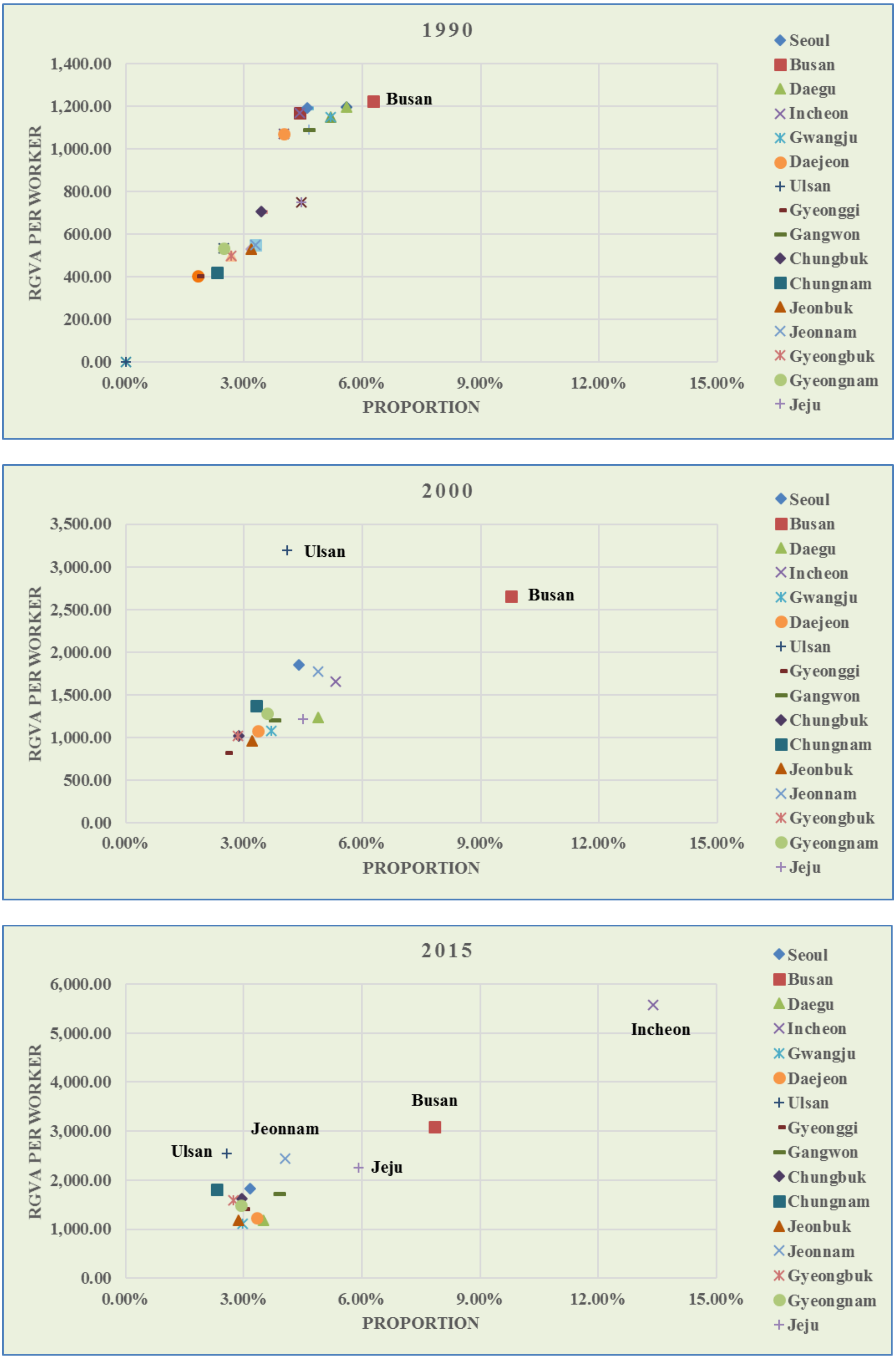


Table 5-1 Classification of the 16 regions by the amount and the proportion in 2015

		GVA per worker	
		High	Low
Proportion	High	Incheon, Busan	
	Mid	Jeonnam, Jeju	Gangwon
	Low	Ulsan	Seoul, Daegu, Gwangju, Daejeon, Gyeonggi, Chungbuk, Chungnam, Jeonbuk, Gyeongbuk, Gyeongnam

On one hand, in the longitudinal sight, the status of transportation in a regional economy is quite different over time. It is likely to be decided whether a region was urbanized or not in 1990. In other words, the metropolitan cities generally had greater GVA per worker in transportation and sectoral proportion of transportation than the provinces. However, through the 1990s, the factors to influence the status may have changed considering the status of transportation in Busan and Ulsan outlay in 2000. Furthermore, the factors have been more influential through the 2000s. Several regions like Incheon, Busan and Jeju have a greater difference in the amount and the proportion.

On the other hand, the status of transportation in a regional economy can be classified by the amount of the GVA per worker in transportation and the sectoral proportion of transportation applied.[77] As shown in Table 5-1, there are six categories. The first group, which Incheon and Busan are included in, is that a regional transportation has both high proportion and high GVA per worker. It can be said that those regions must have the transportation infrastructures to serve the demand from other regions. On the contrary, the sixth group that a regional transportation has both low proportion and low GVA per worker includes Seoul, Daegu, and Gwangju etc. It implies that the regions may have comparatively smaller supplies for transport service than the demands generated in their administrative boundary. In this context, the other groups have the features between the first group and the sixth group. For example, the second group, which Jeonnam and Jeju are in, can be understood that the regions supply the transport services to other regions and there is the considerable amount of influx in the GVA per worker in transportation. In the case of Ulsan, it can be understood that the regional economy create quite huge GVA per worker in transportation but the considerable amount of the transport demand is handled by the transport services from the other regions.

From the results above, this study suggests that the different status of transportation among regions may have been derived from the presence of the huge scaled commercial port. In this line, this study analyses the four major port regions with the shift-share analysis applied in the following section.

[77] As the criteria of the amount, the GVA per worker of 1,940 thousand KRW in the national transportation in 2015 is applied. Meanwhile, the figures are applied in the sight of the proportion. The one which separates mid group and low group is 3.8% of the proportion of transportation in the national economy in 2015 is. The other between high group and mid group is 6%, which is the arbitrary criteria by the author’s intuition.

5.3 Comparative Understanding for Four Regions

This study overviews briefly the changes in the GVA per worker in transportation in the various sights in the previous section. Considering the results, this study investigates the changes of the GVA per worker in transportation in four major port regions mainly by applying the comparative analysis based on the results of the shift-share analysis in Appendix 4 Shift-share Analysis.

5.3.1 General information of four regional economies

General information on four regional economies focused on the GVA per worker in transportation are shown in Table 5-2. Firstly, in the case of Busan, the GVA per worker increased by about 20 million KRW from 19.6 million KRW in 1990 to 39.4 million KRW in 2015 and the average annual growth rate is 2.84%, which is quite lower than 3.87% in the national economy. The GVA per worker in transportation increased by 1,867 thousand KRW from 1,226 thousand KRW in 1990 to 3,093 thousand KRW in 2015 and its average annual growth rate is 3.77%. Meanwhile, the changes in the GVA per worker in transportation are quite different between the first half and the second half of the studied period. The growth rate is far higher in the first half than in the second half. In the sight of the proportion, transportation experienced up and down from 6.26 % in 1990 through 9.77% in 2000 to 7.84% in 2015. The rank of the sectoral proportion was the seventh in 1990 but moved forward through the fourth in 2000 and 2010 to the fifth in 2015.

Table 5-2 General information of the GVA per worker in four major port regions

(Unit: thousand KRW)

Year		1990	2000	2010	2015
Busan	Total	19,571.81	27,148.61	37,280.51	39,437.90
	Transportation	1,226.54	2,653.08	2,874.72	3,093.55
	Sectoral rank	7	4	4	5
Incheon	Total	26,578.90	31,150.32	41,311.76	41,595.63
	Transportation	1,171.17	1,655.14	5,471.43	5,571.33
	Sectoral rank	7	7	2	2
Ulsan	Total		77,937.28	91,411.88	98,768.99
	Transportation		3,195.77	2,547.25	2,541.76
	Sectoral rank		2	4	6
Jeonnam	Total	16,668.18	36,474.85	57,668.16	60,123.09
	Transportation	547.69	1,774.88	2,415.23	2,438.26
	Sectoral rank	8	6	5	5

Source: compiled by the author from KOSIS (2017).

Secondly, the GVA per worker in Incheon increased by about 15 million KRW from 26.6 million KRW in 1990 to 41.6 million KRW in 2015 and the average annual growth rate is 1.81%. As well, the GVA per worker in transportation increased by 4,400 thousand KRW from 1,171 thousand KRW in 1990 to 5,571 thousand KRW in 2015 and its average annual growth rate is 6.44%, which is almost two times as high as 3.84% of transportation in the national economy. The growth rate of GVA per worker in transportation is far higher than the one in the regional economy after 2000. In the sight of the proportion, transportation has increased continuously and steeply from 4.41 % in 1990 through 13.24% in 2010 to 13.39% in 2015. The rank of the sectoral proportion was the seventh in 1990 but stepped forward through the second in 2010 and 2015.

Thirdly, the GVA per worker in Ulsan has ranked in the first place among 16 regions since it separated from Gyeongnam in 1998. The GVA per worker increased by about 20 million KRW from 68.8 million KRW in 1998 to 98.7 million KRW in 2015 and the average annual growth rate for the last 17 years is 2.15%. On the contrary, transportation experienced huge decrease and the stagnant situation in the GVA per worker: in detail, decreasing from 3,051 thousand KRW in 1990 to 2,547 thousand KRW in 2010 and has been moving up and down around 2,500 thousand KRW. In the sight of the proportion, transportation has decreased continuously and steeply from 4.1 % in 2000 through 2.78% in 2010 to 2.57% in 2015.

Lastly, the GVA per worker in Jeonnam increased by about 43.4 million KRW from 16.7 million KRW in 1990 to 60.1 million KRW in 2015 and the average annual growth rate is 5.27%, which is far higher than 3.87% of the one in the national economy. As well, the GVA per worker in transportation increased by 1,891 thousand KRW from 547 thousand KRW in 1990 to 2,438 thousand KRW in 2015 and its average annual growth rate is 6.16%, which is far bigger than 3.84% of transportation in the national economy. It experienced an explosive increase for the 1990s but a contemporary decrease during earlier of the 2000s. In the sight of the proportion, transportation has increased continuously and steeply from 3.28 % in 1990 through 4.86% in 2000 to 4.05% in 2015. The rank of the proportion was the eighth in 1990 but stepped forward the fifth in 2010 and 2015.

5.3.2 Changes in transportation

5.3.2.1 Shift-share analysis

The shift-share analysis is good to understand the characteristics of the changes in the GVA per worker of transportation. The results of the shift-share analysis[78] are presented in Figure 5-15. The

[78] In the conventional research with shift-share analysis applied, the results are presented by the shape of the table which contains the numeric changes of four variables. However, this study applies the dynamic version of shift-share analysis with 25 sub-periods so the results are too big to be expressed by the table. In addition, the graph is better to show the trend of the changes than the table. By these reasons, this study supply the results

total growth (TG), the growth effect (GE), the industrial mix (IM) and the competitive effective (CE) are expressed by the different-coloured lines. At a glance, the shapes of four lines look confusing slightly but the meaning[79] of the results are not so complicated. Firstly, in the case of Busan, the TG shows that the GVA per worker of transport increased even faster by the earlier 2000s than the national growth rate but decreased steeply since the later 2000s. Entering this decade, the GVA per worker turned to the growth and was in the trend that the fluctuation in the GVA per worker is getting stable at the latest decade. Looking at what made GVA per worker fluctuated, the relationship both between TG and IM and between TG and CE is very important. The former shows how much changes in TG come from the growth of transportation in the national economy and the latter shows how much changes come from some causes based on the characteristics of Busan regional economy. In conclusion, the graph shows that the fluctuation in GVA per worker is mainly from the characteristics of transportation in Busan regional economy such as the capacity of transport infrastructure, the proportion of sub-sectors in transportation, and the geographical characteristics, etc.

Secondly, the results in Incheon can be interpreted in the same way. The TG shows that the GVA per worker of transportation in the regional economy increased explosively in several sub-periods; 2000-2001 to 2006-2007. Especially, the GVA per worker became almost doubled in 2000-2001 and continued to be in the explosive increase for the 2000s. Meanwhile, the growth of the GVA per worker lessened and has been coupling to the GE and IM in the 2010s. As a result, the changes in the GVA per worker resulted from CE much more than IM during the 2000s but are getting closer the trend of IM than one of CE. It means that the fluctuation in GVA per worker is mainly from the characteristics of transportation in Incheon during the 2000s but is coupling to the growth of transportation in the national economy. It is mainly because the scale of transportation in Incheon became big enough to influence to the growth rate of transportation in the national economy.

Thirdly, the GVA per worker in transportation in Ulsan had decreased rapidly by earlier of the 2000s and kept stagnant after then. The TG shows that there was a huge decrease in GVA per worker by

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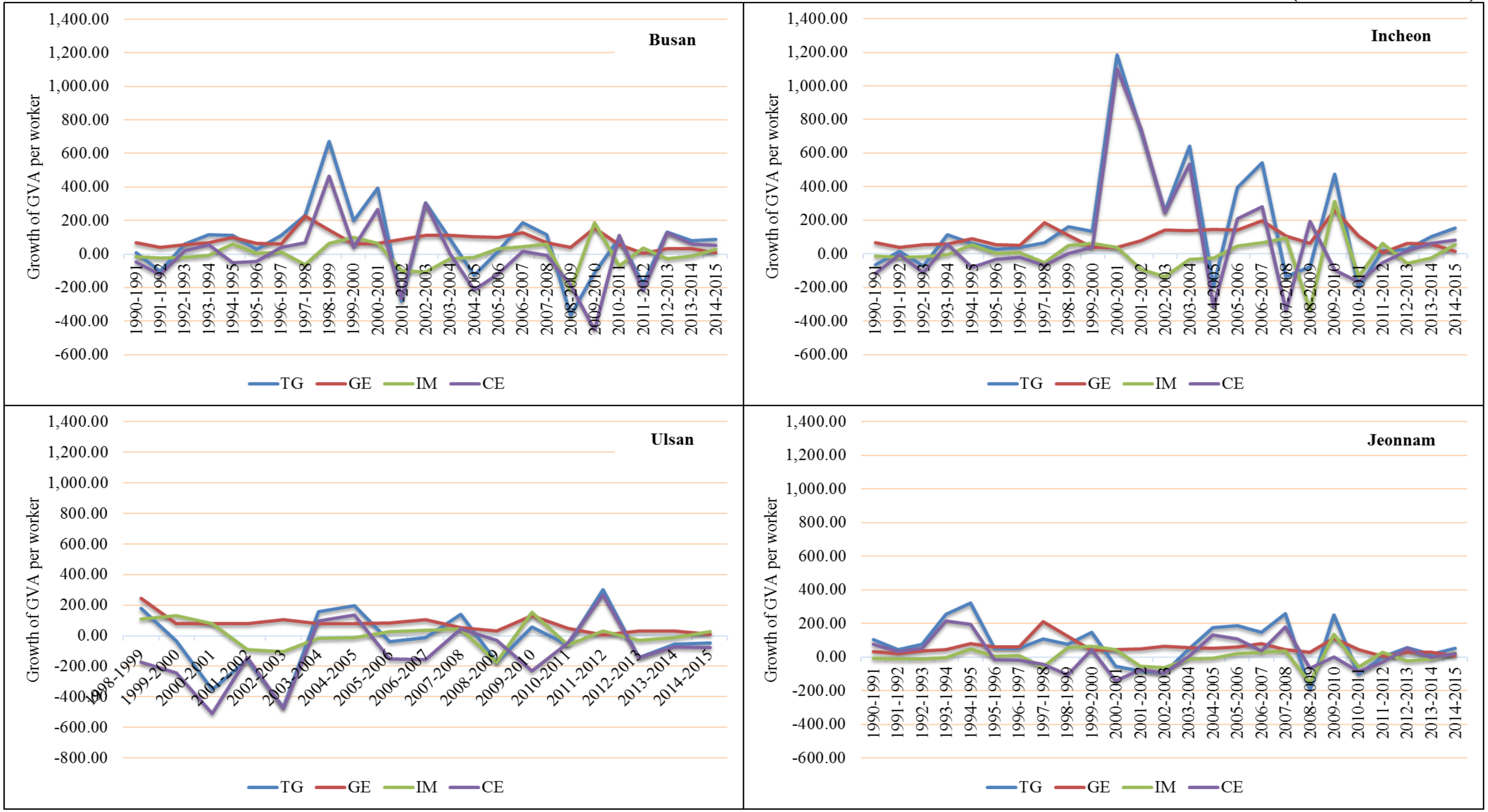
of shift-share analysis by the line graph which has strengths to show the trend of variable even though this study can’t present the exact figures of the changes.

[79] How to understand the results, which show how much they changed over time not what the changes come from, is same with the conventional research below.

- TG is the real changes in GVA per worker between the time periods compared.
- GE is the expected growth in GVA per worker based on the assumption that GVA per worker of a regional transport would grow as much as the whole national economy so it shows how the nation economy changes.
- IM is the estimated growth derived from the gap between the growth rate of the national economy and the growth rate of transportation in the national economy. It shows how fast transportation has grown compare to the whole national economy
- CE is the estimated growth derived from the gap between the growth rate of transportation in the national economy and the growth rate of a regional transportation. It show how fast transportation in a regional economy changed compared to transportation in the national economy.

Figure 5-15 Results of the shift-share analysis of a regional transportation in four port regions

(Unit: thousand KRW)



Source: Song and Preston (2018).

Table 5-3 Results from correlation analysis of variables from shift-share analysis and port traffics

	Busan				Incheon				Ulsan				Jeonnam			
	TG	GE	IM	CE	TG	GE	IM	CE	TG	GE	IM	CE	TG	GE	IM	CE
TG	1.000				1.000				1.000				1.000			
GE	0.332	1.000			0.201	1.000			-0.175	1.000			0.266	1.000		
IM	0.349	0.145	1.000		0.245	0.299	1.000		0.085	0.355	1.000		**0.676**	0.113	1.000	
CE	**0.886**	0.052	-0.060	1.000	**0.903**	-0.092	-0.157	1.000	0.294	**-0.488**	-0.163	1.000	**0.813**	-0.164	0.263	1.000
RT	0.194	-0.087	0.404	0.069	0.020	-0.040	**0.521**	-0.159	-0.110	-0.178	-0.050	0.338	0.323	-0.036	**0.623**	0.070
TEUp	0.228	0.184	**0.458**	0.018	0.301	**0.610**	**0.533**	0.005	0.137	0.195	**0.574**	-0.241	0.070	0.265	**0.385**	-0.252
TEUr	**0.438**	0.205	**0.460**	0.247	0.297	**0.595**	**0.537**	0.001	0.137	0.195	**0.574**	-0.241	0.022	0.293	0.330	-0.296

Source: Song and Preston (2018).
Note: * RT; port traffics measured by revenue tonne, TEUp; port traffics of a port measured by TEU, TEUr; port traffics of a region measured by TEU.
** The critical value at the 5% significance in the two-tailed test with 23 degrees of freedom except for PT(RT) whose ones are 19 is between 0.423 (20) and 0.381 (25).

the earlier 2000s. After then, the growth and the minus growth continue to repeat by 2015. Looking at how much GVA per worker moved, the TG is quite lower than the growth shared from the GE and the IM by the earlier 2000s. Furthermore, the TG is usually lower than the GE and the IM even after the mid-2000s except for three years: 2004, 2005, and 2012. It can be understood that the changes in the GVA per worker result from some regional specific factors.

Lastly, the GVA per worker of transport in Jeonnam shows three periods with a pattern shared: 1990-1991 to 1996-1997, 1997-1998 to 2002-2003, and 2003-2004 to 2014-2015. In the first period, the GVA per worker increased continuously and steeply while depending on some factors based on the regional economy. In other words, the TG was bigger than the one derived from GE and IM. In the second period, the TG was supported by the GE rather than the IM or the CE. On the other hand, in the last period, the TG has moved together with the GE, the IM and the CE coupled more and more.

5.3.2.2 Correlation analysis

The correlation analysis between the variables of the shift-share analysis supplies the statistical significance for the result above as shown in Table 5-3.[80] The table supplies two different types of statistical information. On one hand, it delivers how strongly the TG is correlated with the other three components of the shift-share analysis. In this aspect, the results in Busan, Incheon and Jeonnam show that the TG is quite strongly correlated with the CE more than the GE and the IM. However, in the case of Ulsan, the TG is comparatively less correlated with the growth of the national economy and the national transportation.

[80] The correlation analysis was conducted between the four components from shift-share analysis of RGVAt/w and the annual changes of port traffics after converting annual port traffics to annual change in the same way as shift-share analysis.

On the other hand, the table also supplies how strongly four figures from the shift-share analysis are correlated with the changes in port traffics. At a glance, it can be said that the relationship between the four components from shift-share analysis and three different types of port traffics is very different for each port. In the case of Busan, the TG has a higher correlation with the growth of annual container freights measured by TEU than the one of total freight volume measured by RT; especially, container freights by the criteria of the administrative boundary of Busan rather than of the Port of Busan[81]. This can is interpreted as reflecting the fact that container freights account for the largest proportion of the Port of Busan traffic in the aspect of the cargo composition. In the case of Incheon, the TG is correlated relatively more with the change of container freights by TEU than the one of the total cargo by RT. Meanwhile, the amount by TEU in the port is almost identical to the one in the boundary of Incheon. However, Ulsan has very different results compared to other ports. The TG is negatively correlated with the change of the total volume by RT but positively done with the one of the container freights by TEU. However, the CE is in the totally different correlation between the former and the latter. It might be rooted in the features of the Port of Ulsan such as cargo compositions, the service boundary and the relationship between the port and the end users, etc. Finally, in the case of Jeonnam, the TG has the higher correlation with the change of the cargo volume measured by R/T than the one of the container freights, even though the Port of Gwangyang is handling the amount of container freights which account for around 20% out of the total cargo in the criteria of RT.

From the discussion above, it can be concluded that similar figures from port-related activities including port traffic measured by RT and by TEU can have different meaning both in practice and in statistics among ports which have been in the different context. In addition, port-related activities may make different economic impacts in different linkages with other activities in transportation and other industries according to the features of an individual port. As a result, economic impacts of ports need to be interpreted based on the contextual understanding of an individual port in relation with the regional economy and the national economy. In this line, this study proposes the significant point that shift-share analysis can function as the preliminary methodology to show the big picture with regard to the characteristics of ports at the level of macro- or meso-economy, but not the alternative one of existing methodologies at the level of micro-economy.

[81] The Port of Busan has the New Port which is located partially in Busan. In addition, the distribution centres behind the container terminals in the New Port are included in two different administrative boundaries. For this reason, this study calculated the amount of annual container freights by the criteria of a port and administrative boundary. As a result, the significant amount of container freights have been handled in the boundary of Gyeongnam since 2009. As a result, the amount of container freights in the Port of Busan has increased but the one in the Busan Metropolitan City experienced decrease contemporarily around 2010.

5.3.3 Changes in four sub-sectors of transportation

The results in the previous section can be elaborately understood by looking at four sub-sectors in transportation. To do so, this study introduces the overview and the application of the shift-share analysis at the level of four sub-sectors in transportation. Meanwhile, the procedure is focused on land transport and transport supporting activities considering the relationship with port activities.

5.3.3.1 Overview of the changes

Firstly, in the case of Busan, the GVA per worker of land transport decreased by 381 thousand KRW to 1,630 thousand KRW in 2015 as shown in Figure 5-16. The one in water transport increased by 308 thousand KRW to 586 thousand KRW in 2015. The one in transport supporting activities increased by 433 thousand KRW to 877 thousand KRW in 2015. As a result, the proportion of land transport decreased from 76.5% in 2000 to 52.7% in 2015. However, the two sub-sectors increased its proportion respectively from 6.74% and 16.76% in 2000 to 18.95% and 28.35% in 2015.

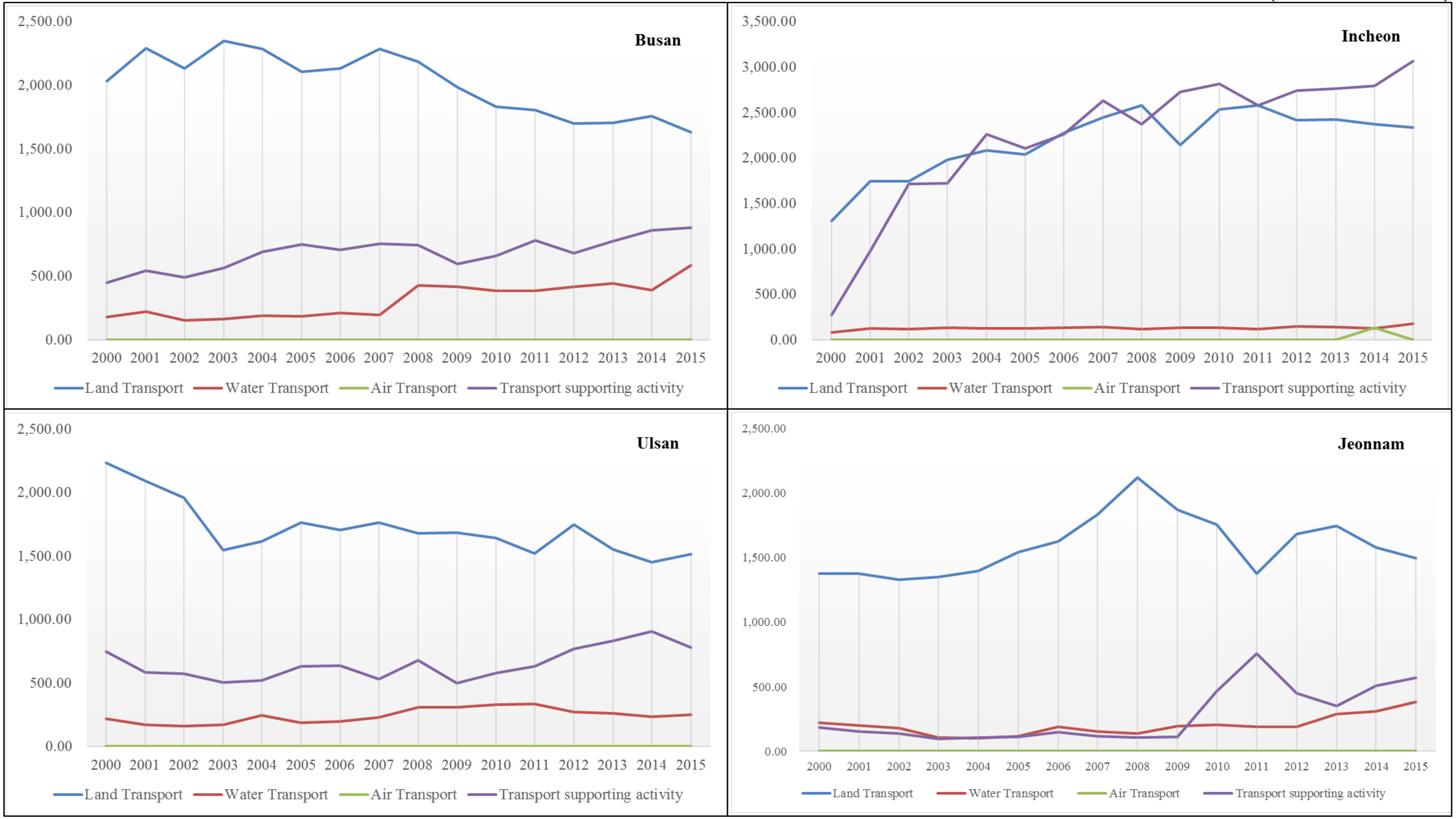
Secondly, in the case of Incheon, the GVA per worker of land transport increased by 928 thousand KRW from 1,306 thousand KRW in 2000 to 2,334 thousand KRW in 2015. The one in water transport increased by 93 thousand KRW from 79 thousand KRW in 2000 to 172 thousand KRW in 2015. The one in transport supporting activities increased by 2,795 thousand KRW from 269 thousand KRW in 2000 to 3,064 thousand KRW in 2015. As a result, transport supporting activities increased its proportion by 38.71% points to 55.00% in 2015. Meanwhile, land transport and water transport decreased respectively by 37.01% points and 1.69% points to 41.91% and 3.10% in 2015.

Thirdly, in the case of Ulsan, the GVA per worker of land transport decreased by 718 thousand KRW from 2,233 thousand KRW in 2000 to 1,515 thousand KRW in 2015. Meanwhile, the GVA per worker in water transport and in transport supporting activities sidled along. Water transport increased the GVA per worker by 30 thousand KRW to 246 thousand KRW in 2015. Transport supporting activities increased by 34 thousand KRW to 779 million KRW in 2015. As a result, the proportion of land transport decreased from 69.89% in 2000 to 59.64% in 2015. On the other hand, water transport and transport supporting activities increased their proportion respectively by 2.92% from 6.78% in 2000 to 9.70% in 2015 and by 7.33% from 23.33% in 2000 to 30.66% in 2015.

Lastly, in the case of Gwangyang, the GVA per worker of land transport increased by 928 thousand KRW to 1,493thousand KRW in 2015. However, the one in water transport and transport supporting activities increased respectively by 160 thousand KRW to 378 thousand KRW in 2015 and by 384 thousand KRW to 566 thousand KRW in 2015. As a result, the sectoral proportion of land transport decreased from 77.38% in 2000 to 61.26% in 2015. Meanwhile, the two other sub-sectors increased respectively from 12.30% and 10.30% in 2000 to 15.51% and 23.23% in 2015.

Figure 5-16 Annual GVA per worker of four sub-sectors in a regional transportation

(Unit: thousand KRW)



5.3.3.2 Land Transport

Above all, as shown in Figure 5-17, land transport in Busan has experienced the continuous decrease that TG has recorded the negative growth in most of the studied periods except for five terms: 2000-2001, 2002-2003, 2006-2007, 2012-2013, and 2013-2014. Furthermore, the magnitude of the change in the negative growth is much bigger than in the positive. As well, the sub-periods that the TG increased much more than the GE are just four: 2000-2001, 2002-2003, 2006-2007, and 2013-2014. This trend is derived mainly from the IM, which is green-lined, and the CE, which is purple-lined. The IM shows that land transport in the national economy has developed later than the whole national economy. Furthermore, the CE shows that land transport in Busan recorded quite a bigger decrease than one in the national economy. As a result, it can be understood that land transport had been in the severe decrease in the 2000s and has not escaped the decreased trend in the 2010s yet mainly due to the decreased trend in the national transportation and some regional specific factors.

Secondly, in the case of Incheon, land transport has been on the increasing trend in GVA per worker. Even though the GVA per worker decreased in several sub-periods: 2001-2002, 2004-2005, 2008-2009, and 2011-2012, the magnitude of the growth is much bigger than the one of the negative growth. Meanwhile, the magnitude of annual growth is getting smaller and is getting closer to the GE so that the GVA per worker shows the stable changes in the latest decade. This trend seems to be derived mainly from the CE rather than the GE and the IM by the 2000s. Even though the GE shares a small amount and the IM shares the negative growth, the TG shows the positive growth thanks to the growth in the CE. It can be said that land transport has owed its growth to some characteristics of transportation in the Incheon regional economy.

Thirdly, in the case of Ulsan, land transport has been in the decreasing trend in GVA per worker. Even though the growth for GVA per worker was positive in several sub-periods; 2003-2004, 2004-2005, 2006-2007 and 2011-2012, the magnitude is much bigger in the negative growth than the opposite. Furthermore, the GVA per worker is getting closer to the trend of the IM. Meanwhile, the magnitude of annual changes was getting smaller by the later 2000s but is getting bigger since the earlier 2010s mainly due to some regional characteristics.

Lastly, in the case of Jeonnam, land transport has been stagnant even though it experienced a huge up and down in the GVA per worker. From 2000 to 2008, the GVA per worker of land transport increased faster than the one in the national economy. However, it decreased slightly between 2008 and 2012. In the end, land transport in Jeonnam has been in the lower growth in the recent years than the one in the national economy. The interesting characteristic of land transport is that the TG and the CE have moved with quite a similar pattern. It can be said that land transport has owed its fluctuation to some characteristics of land transport in the regional factors.

Figure 5-17 Results of the shift-share analysis for GVA per worker of land transport

(Unit: thousand KRW)

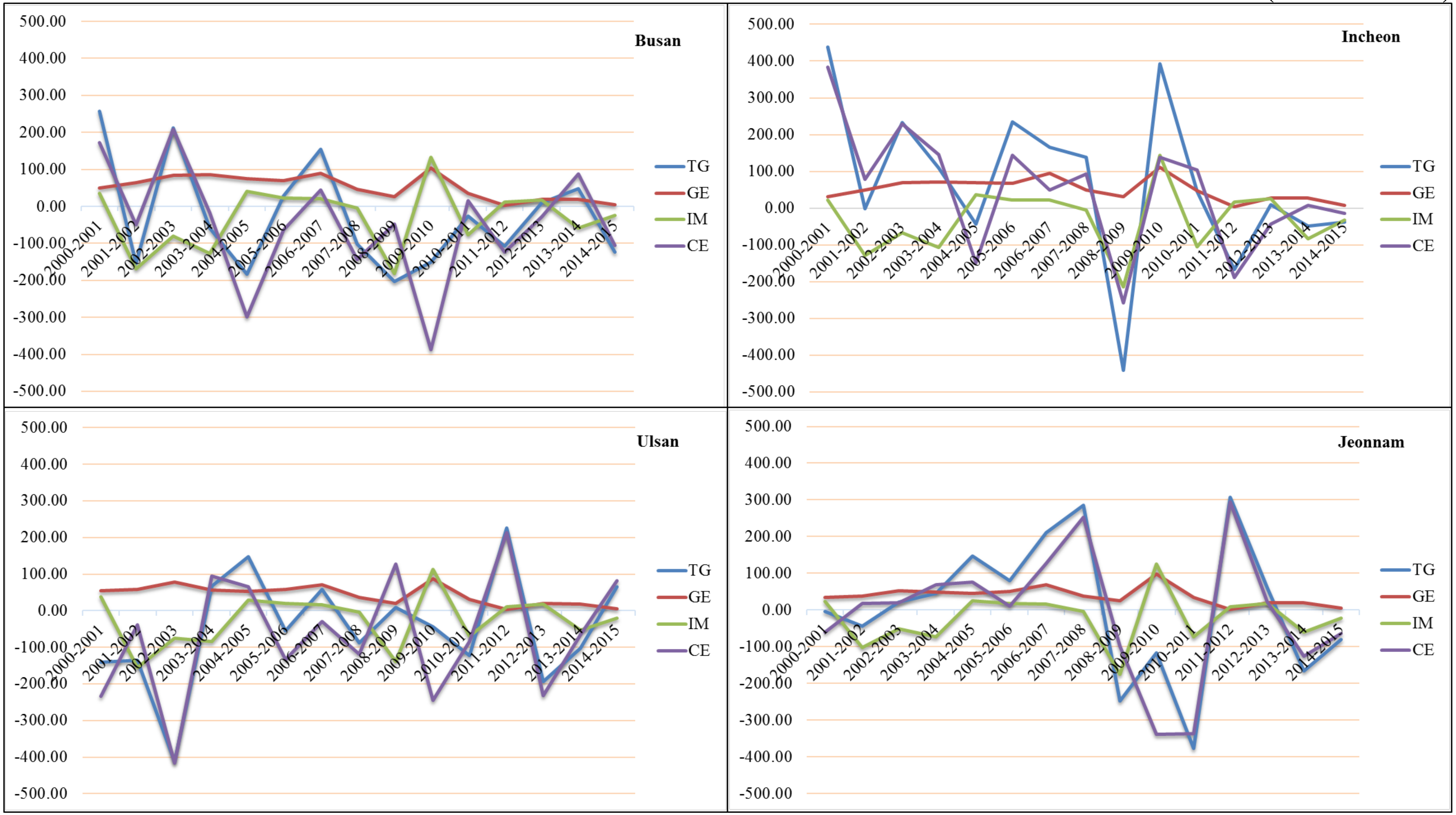
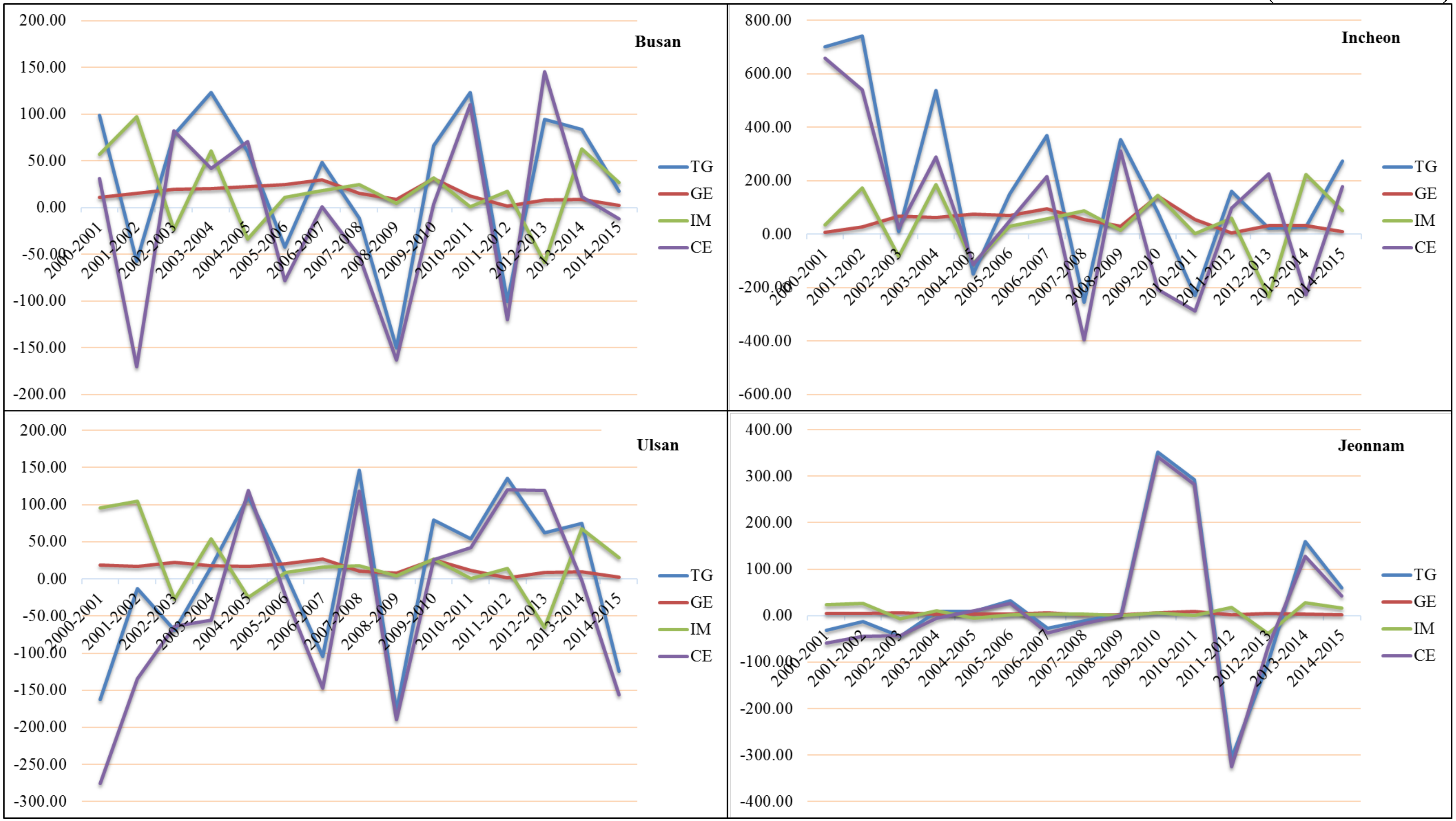


Figure 5-18 Results of the shift-share analysis for GVA per worker of transport supporting activities

(Unit: thousand KRW)



5.3.3.3 Transport Supporting Activities

Firstly, as shown in Figure 5-18, the GVA per worker in transport supporting activities in Busan shows that a steep increase and a rapid decrease are repeated without the specific trend. Furthermore, the magnitude of changes is considerably huge compared to land transport. Meanwhile, the top and the bottom of the TG are getting higher so that the accumulated TG is positive and the GVA per worker is increasing faster than the one in transport supporting activities in the national economy. In the sight of the relationship with other lines, the TG is moving considerably similar to the CE. As a result, it can be said that transport supporting activities have moved mainly by the influence of the regional characteristics and has been decoupling more and more with transport supporting activities in the national economy.

Secondly, in the case of Incheon, the GVA per worker in transport supporting activities continue to increase explosively. The growth of the GVA per worker is much bigger in the earlier 2000s than the one of land transport, which was the biggest sub-sector in 2000. The growth in the magnitude is far bigger than the negative one, even though the growth of the GVA per worker repeatedly fluctuated by a huge amount as both the top and the bottom are getting lower by the later 2000s. After then, the fluctuating trend turned to the continuous increase. Meanwhile, the TG and the IM show that transport supporting activities in Incheon moves in the same direction as the one in the national economy. Nevertheless, the growth of transport supporting activities in Incheon is likely to be influenced by some regional factors far more than some factors related to the national economy.

Thirdly, in the case of Ulsan, the GVA per worker in transport supporting activities repeat up and down. It had recorded the negative growth for the early 2000s and repeated rapid increase and steep decrease by the late 2000s. Entering this decade, it has a tendency to increase faster than the one in transport supporting activities in the national economy. To evaluate the changes comprehensively, transport supporting activities in Ulsan is developing little by little but more slowly than one in the national economy.

Lastly, in the case of Jeonnam, the GVA per worker in transport supporting activities continue to decrease by 2009. However, it jumped up by such a huge amount in 2010 and 2011 but fell down in 2012 as big as one in 2011. During the last two years, it has grown much faster than one of transport supporting activities in the national transportation. On the other hand, the TG and the IM show that the changes of transport supporting activities in Jeonnam are pretty bigger than the ones of transport supporting activity in the national economy. Considering these features, the growth of transport supporting activities in Jeonnam can be understood to result from some regional factors far more than some factors related to the national economy.

5.3.4 Summary

This study introduces the results of the comparative study by applying the shift-share analysis for the four major port regions. Firstly, this study examines the general information of the four regional economies and the proportion of transportation as a sector of each regional economy over time. As a result, the status of transportation in the three regional economies of Busan, Incheon and Jeonnam have been greatly improved, but the one in the case of Ulsan has dropped quite fast. Secondly, this study examines the changes in the annual GVA per worker of transportation and the correlation analysis between the four variables from the shift-share analysis. The results suggest that the changes in the GVA per worker of transportation in the three regions of Busan, Incheon and Jeonnam are mainly related to some factors rooted in the individual regional economy. Meanwhile, the ones in Ulsan are rooted in the structural changes in the national transportation as much as some features in the regional economy. Lastly, this study examines the changes in the four regional transportation by repeating the application of the shift-share analysis to the GVA per worker and the comparative understanding at the level of the four sub-sector in transportation. Meanwhile, the second analysis is conducted only for land transportation and transport supporting activities, considering the relationship with the port-related activities. As a result, this study shows that the four regions have large differences in both the structural composition and the annual growth rate over time due to some regional specific factors.

5.4 Findings

This study longitudinally analyses the changes in the annual GVA per worker by applying various methods such as the descriptive analysis, the shift-share analysis, the correlation analysis and the comparative one in the various perspectives. As a result, this study discusses the characteristics that the GVA per worker has shown in the transportation and the whole economy at the level of the nation and the region in the sight of a sectoral and regional composition. The key findings can be summarized as follows.

5.4.1 Status of Transportation

Above all, from a longitudinal perspective, the GVA per worker in transportation is analysed to have gone up and down over time. The Korean economy has grown steadily for the studied period thanks to the consistent growth of the manufacturing: in detail, the GVA of the manufacturing accounted for 20.34% of the national economy in 1990 but 33.93% in 2015. The manufacturing-oriented economic growth must have contributed greatly to the growth of transportation in the 1990s. However, after the application of the IMF bailout in 1997, the growth trend of transportation have severely been damaged by the fundamental changes: for example, the electronics-focused growth of the national economy and the extensive efforts of reducing the logistics costs by Korean companies (MCT, 2006). As a result, even though transportation has grown in the amount of the GVA per worker, but the sectoral proportion in the national economy has been shrunk since the 2000s. It is analysed to fluctuate around 3.8% in the 2010s.

Secondly, from the sight of the sectoral decomposition, transportation in the Korean economy has been undergoing a rapid change for the overall studied periods. In the sight of the regional share, Seoul has experienced the rapid and continuous decrease in the proportion in the GVA of the national transportation by more than 15 percentage points, while Gyeonggi and Incheon have strengthened their shares by more than 10 percentage points. It results partially from the trend that the logistics companies in Seoul have moved to Gyeonggi and Incheon (MLTM, 2011c). On the other hand, in the sight of the sectoral share, transportation has been in a drastic change with regard to the share of its four sub-sectors. Especially, land transportation has accounted for the greatest proportion of transportation but has been steadily decreasing since 2000. On the contrary, transportation supporting activities have been steadily increasing their share as the second largest sub-sector.

Lastly, the status of transportation in a regional economy has changed continuously and drastically. The proportion of transportation in the individual regional economy, measured by the GVA per worker, has greatly varied over time. In the early 1990s, the difference in the sectoral share of transportation between the 16 regional economies was not huge. As well, the one seemed to result mainly from the presence and the extent of the urbanization and/or the industrialization. However, after the early 2000s, the regional disparity can be evaluated to increase gradually in both the amount of the GVA per worker in transportation and the sectoral proportion of transportation in a regional economy. Especially after the late 1990s, it can be inferred that the presence of transport nodes such as a large-scale seaport and/or an international airport have influenced much more the sectoral status of transportation than the extent of urbanization and/or industrialization.

5.4.2 Changes of transportation

Based on the above results with regard to the changes in the Korean economy and transportation, this study proposes some important findings derived from the analyses of the four major port regions. First of all, transportation in the four port regions has shown such a different feature in terms of the annual GVA per worker. Especially, transportation in Busan, Incheon, and Jeonnam has experienced so large growth in the mid-1990s, the early 2000s, and the late 2000s, respectively. After then, transportation is likely to be coupled to the changes in the national transportation.

Secondly, the annual changes in one in the four regions have been significantly different from the growth rate of the national economy and the growth rate of the national transportation. The magnitudes of the changes are too huge to result from the overall growth of the national economy and/or the structural changes in the national transportation. As a result, the changes in the GVA per worker in each region is reasonable to understand the result of reflecting some characteristics rooted in individual regions such as the presence of transportation nodes such as a large-scaled seaport and the agglomerated logistics centres. From this point of view, this study suggests the key factors of the changes in the GVA per worker of transportation in the four regions as follows. In the case of Busan, it can be interpreted that transportation has grown rapidly since the mid-1990s when the container cargos began to increase explosively due to the movement of transhipped cargos from the Port of Kobe. As well, Incheon has experienced explosive growth for the 2000s after the Incheon International Airport opened in 2000, and it has gradually coincided with the growing trend of the national transportation as entering the late 2000s. In the case of Jeonnam, it is considered that the growth in the late 2000s has been undergone under the influence of the development of container dedicated facilities at the Port of Gwangyang. On the contrary, in the case of Ulsan, the cargo-type composition and the port facilities focused on raw materials seem to result in the negative growth in the GVA per worker of transportation. It is reasonable as considering that the role of the port has focused on supporting the logistics demands generated in the adjacent industrial complex.

Lastly, the difference in the GVA per worker of individual sub-sectors in transportation is more noticeable. In the case of Busan, while the GVA per worker in land transport has been in the decreasing trend, transport supporting activities and maritime transport have experienced in the large growth. This pattern is similarly observed in Ulsan. On the other hand, in the case of Incheon, the growth of transport supporting activities is outstanding. As a result, transport supporting activities have overtaken land transport in the sectoral proportion and occupies the largest share, even though the latter has been in the steady growth. In the case of Jeonnam, land transport, transport supporting activities and water transport have steadily grown even though the first two sub-sectors had a big drop in the late 2000s.

5.4.3 Comprehensive evaluation

This study suggests that the results have several implications. Firstly, it can be suggested that the influence of a large-scale port to the annual changes and the regional difference in the GVA per worker of transportation is considerable. It is significant that the proportion of the port-related activities in the national economy or transportation is quite small. This can be supported by the difference in the GVA per worker between the regions with seaports and the inland regions. As well, this may be backed up statistically by the econometric analysis in the following chapters.

Secondly, the result above implies that it is necessary to consider the structural characteristics of port-related activities such as the cargo composition and the service boundary as well as the cargo traffic when analysing the economic impact of ports with port traffics applied. This is since the gaps in the GVA per worker among the four regions are significantly great compared to the disparity in the amount of the port traffics among the four ports. Meanwhile, it is reasonable to conclude that the GVA per worker of transportation in Busan and Incheon are comparatively high due to the features in the composition of cargo types and the boundary for service discussed in the previous chapter.

Thirdly, the above results give the implication to the port studies from the theoretical point of view. On one hand, the results are interpreted to correspond to the mainstream in port studies that the port-related activities have been in the intensification of the functional integration with various logistics activities: especially, value-added activities in the logistics centres. In addition, the results seem to be in line with the argument that the functional range of the port has been expanding by strengthening the connection with land transport and logistics activities centred on the container port.

Lastly, the results provide meaningful implications to the econometric analysis in the next chapter. On one hand, the four regions are necessary to be considered to be heterogeneous in terms of the sectoral structure. On the other hand, it should be considered that the regions with large-scale ports have the strong relationship with the other regions by supplying the transport services. In other words, it should be considered sufficiently the interdependence in the process of analysing the data and the results of the econometric analysis.

Chapter 6 Econometric Analysis

6.1 Introduction

It is not until the 1950s that economists began to have interest in port research and since then, various economic methodologies were gradually applied in port studies (Heaver, 2006). However, it is only after the 2000s that port research began to study the economic performance of ports using the panel data from regional accounts (Woo et al., 2011). In addition, more recently econometric analysis based on the long-term economic growth model began to be applied (Park and Seo, 2016).[82] As a result, this study conducts an analysis based mainly on the econometrics approach rather than the previous research in port studies such as Shan et al. (2014) and Park and Seo (2016).

The econometrics for the empirical analysis are generally following the similar procedure such as specification, calibration and validation (Asteriou and Hall, 2015).[83] Meanwhile, this chapter mainly handles the works related to calibration and validation such as testing for the data, estimating parameters, and examining the goodness of fit. As the starting point of the empirical analysis, the stationarity test for the panel data is conducted by applying the unit roots test and the co-integration test. After then, this study follows a modified procedure as considering that the sub-group analyses are implemented; namely, the model selection, the parameter estimation and the post-estimation tests are conducted using the basic regression function and then the sub-group analyses are done. Then, the causality test is conducted with the explanatory variables.

As a result, this chapter constitutes the following sections that introduce each stage in the empirical analysis. In the next section, a descriptive analysis shows the features of the variables among regions. In the third section, the test for the data is located. In the fourth section, the whole procedure of the econometric analysis is introduced with the basic model applied. In the fifth section, the sub-group analyses are handled. The Granger causality test is discussed in the sixth section and the findings are in the last section.

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[82] From the literature review, why econometric analyses for the panel data are applied in port studies for the recent can be compressed as below.

- Data: the panel data generated from regional accounts dates back to the 1990s.
- Economic theory: the economic growth model has proliferated to the various principles after the augmented Solow's growth model by Mankiw et al. (1992).
- Research objective: port research focuses on the amount of the economic impacts of ports mainly in order to convince the stakeholders to agree with the port development projects.
- Viewpoint: the economic impacts of ports are focused at the level of the national economy rather than at the level of the regional economy until the 1990s.
- Methodology: port research have depended on the IO analysis according to the objective.

[83] The procedure of empirical analysis is generally similar but the categorization is different by the author. This study would summarise the main stages as specification, calibration and validation. The pre-works for the analysis and the specification of the regression function are introduced in the chapter of research design.

6.2 General Information of the Analysis

6.2.1 Understanding of the data

This study uses the panel data with two dimensions of a cross-sectional dimension and a time-series dimension; namely, showing how the variables in each region have changed over time (Hsiao, 2014, p.8-12). Panel data began to be generated since the 1960s in order to observe how individual and household income varies from year to year (Baltagi, 2008). However, it has become an important data format in the macroeconomic and regional economies over time, thanks to the statistical advantages (Hsiao, 2007, p.4-6).[84]

The panel data are getting diverse as fast as the research area which the panel data applied in; in the sight of a panel unit, from an individual or a household to a company, a region and a country and in the sight of a time-series, from short panel (2 or 3 years) to long panel (over 30 years). On the other hand, the panel data is likely to classify the balanced panel and the unbalanced panel depending on whether the same time series period is applied to each panel (Frees, 2004). This is often the critical criteria to select the model as discussed in the next section.

The results of the descriptive analysis, as shown in Table 6-1, show the statistics of the major variables of the 16 regions for the studied periods. In the aspect of statistics, the data used in this study have several characteristics as follows. Firstly, the data set is the unbalanced panel data which individual panels in a region have different length in the sight of the studied period. On one hand, the values of GVA per worker and several variables are gathered since 1990 and have 26 observations from 1990 to 2015. On the other hand, several variables are gathered for the shorter period; for example, the capital depreciation since 1993, the ratio of income invested in physical capital since 1995, the road density since 1991, and the port cargo traffics by RT since 1994. Secondly, the data consist of both quantity variables and ratio variables. The quantitative variables are the GVA per worker and the transport-related variables such as road density (lane-kilometres per worker) and three different port traffics. On the other hand, this study applies three kinds of the ratio variables such as the ratio of capital depreciation, the ratio of income invested in physical capital and the ratio of income invested in human capital. Lastly, each value of the GVA per worker is measured on the price of 2010 but the transport-related variables are not measured in terms of price.

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[84] The advantages compared to the one dimensional data of time-series or cross-section as below;

A. More accurate inference of model parameters because the panel data usually have more degrees of freedom and more sample variability.
B. Greater capacity for capturing the complexity of human behaviour than using cross-section or time series data.
C. Simplifying computation and statistical inference in some cases; analysis of nonstationary time series, measuring errors, and applying dynamic Tobit model.

Table 6-1 Result of the descriptive analysis of the data

		Variables	y	yt	ngd	Sk	Sh	rd	RT	TEUp	TEUr
		Description	GVA per worker	GVA per worker in transportation	Capital depreciation	Ratio of income invested in physical capital	Ratio of income invested in human capital	Road density	Revenue Tonne measured by a port	TEU measured by a port	TEU measured by a region
		Unit	1,000 KRW	1,000 KRW	%	%	%	m^2	tonne	TEU	TEU
		Observation	26	26	23	21	26	25	22	26	26
		Period	1990-2015	1990-2015	1993-2015	1995-2015	1990-2015	1991-2015	1994-2015	1990-2015	1990-2015
1	Seoul	Mean	43,582.08	1,627.84	-0.3265	9.93	27.95	15.09	0.00	0.00	0.00
		SD*	9,818.48	217.07	0.6155	0.96	7.22	1.73	0.00	0.00	0.00
2	Busan	Mean	29,566.76	2,414.01	-0.3822	13.97	18.93	16.04	203,000,000.00	9,617,062.00	8,660,402.00
		SD*	6,855.87	805.27	0.4845	1.81	6.38	4.37	89,400,000.00	5,556,043.00	4,325,617.00
3	Daegu	Mean	26,289.09	1,148.77	0.4285	11.37	19.67	20.10	0.00	0.00	0.00
		SD*	4,473.63	91.59	1.2843	1.23	5.43	4.09	0.00	0.00	0.00
4	Incheon	Mean	34,502.17	3,275.41	1.5848	15.46	15.12	17.84	128,000,000.00	1,043,787.00	1,043,787.00
		SD*	5,409.31	1,860.70	1.4396	2.13	4.45	2.30	18,200,000.00	774,341.00	774,341.00
5	Gwangju	Mean	30,654.65	1,087.60	0.8609	11.95	24.69	23.08	0.00	0.00	0.00
		SD*	5,319.78	107.50	0.6317	1.52	7.34	3.98	0.00	0.00	0.00
6	Daejeon	Mean	32,306.37	1,058.71	1.3331	18.41	25.49	25.67	0.00	0.00	0.00
		SD*	3,524.32	123.95	1.2205	1.57	7.92	2.00	0.00	0.00	0.00
7	Ulsan	Mean	88,652.87	2,665.47	0.8907	18.22	17.69	28.66	161,000,000.00	225,724.20	225,724.20
		SD*	8,872.46	268.84	0.3410	2.30	3.92	2.28	23,600,000.00	148,391.40	148,391.40
8	Gyeonggi	Mean	34,492.79	912.52	2.8750	18.80	20.75	21.57	54,000,000.00	195,944.50	195,944.50
		SD*	7,727.54	354.83	1.4922	2.57	7.55	2.26	32,200,000.00	218,260.20	218,260.20
9	Gangwon	Mean	34,385.37	1,366.68	0.0374	12.76	14.41	69.27	37,100,000.00	3,217.19	3,217.19
		SD*	6,839.24	251.76	0.5505	1.71	5.77	16.16	6,205,912.00	3,387.36	3,387.36
10	Chungbuk	Mean	38,562.01	1,136.47	0.5772	18.70	14.38	52.87	0.00	0.00	0.00
		SD*	10,690.28	287.88	0.4661	2.64	4.88	10.33	0.00	0.00	0.00
11	Chungnam	Mean	49,579.33	1,330.91	0.5137	22.45	12.49	43.94	70,500,000.00	17,663.65	17,663.65
		SD*	21,304.19	500.47	1.1331	3.73	5.93	10.10	24,200,000.00	30,675.64	30,675.64
12	Jeonbuk	Mean	31,753.81	931.72	-0.2990	12.32	16.13	49.26	15,000,000.00	31,566.81	31,566.81
		SD*	8,171.74	227.81	0.8136	2.03	5.64	12.16	3,874,353.00	34,258.96	34,258.96
13	Jeonnam	Mean	41,090.17	1,688.39	-0.7244	18.37	10.03	56.22	194,000,000.00	1,126,565.00	1,126,565.00
		SD*	13,840.72	590.88	0.7462	3.83	4.38	17.76	55,200,000.00	964,316.60	964,316.60
14	Gyeongbuk	Mean	40,413.17	1,052.30	-0.2112	23.55	10.56	45.94	55,200,000.00	26,519.46	26,519.46
		SD*	13,664.55	336.05	0.8779	5.89	4.32	11.56	8,232,513.00	50,701.12	50,701.12
15	Gyeongnam	Mean	39,845.19	1,192.52	-0.3782	15.38	15.50	43.28	39,600,000.00	23,854.19	980,513.50
		SD*	9,525.09	286.44	5.1789	1.37	5.27	9.79	13,700,000.00	20,416.99	1,698,065.00
16	Jeju	Mean	28,871.01	1,368.93	0.9763	9.54	15.60	71.31	2,989,153.00	24,961.00	24,961.00
		SD*	6,367.22	413.75	0.6730	1.50	4.02	23.08	583,016.10	26,875.81	26,875.81

Note: SD*; standard distribution

6.2.2 Descriptive analysis

Table 6-1 is very useful in showing some significant features of the 16 regional economies at the macroeconomic level since 1990. Above all, it supplies how much the GVA is generated by region. In terms of the GVA per worker (*y*), Ulsan, Chungnam, Seoul and Jeonnam seem to have experienced relatively higher economic growth than other regions. Meanwhile, in the sight of the GVA per worker of transportation (*yt*), it can be said that Incheon, Ulsan, and Busan have experienced relatively higher economic performance compared to other regions. Secondly, the population growth (*ngd*) has declined in the seven regions such as Seoul, Busan, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, and Gangwon, whilst has increased in the nine regions such as Gyeonggi, Incheon, and Daejeon etc. Thirdly, with regard to the ratio of income invested in the physical capital (*Sk*), any specific difference is not shown between metropolitan cities and provinces. Meanwhile, the ratio seems to be closely related to the proportion of manufacturing industries in a regional economy. Fourthly, unlike the ratio of income invested in the physical capital, the ratio of income invested in the human capital (*Sh*) has a tendency to be higher in urban areas. This is consistent with the general finding that the investment in education is generally higher in urban areas. Fifthly, the road density (*rd*) measured by the lane-kilometres per worker[85] is relatively higher in provinces than in urban areas. It is since the provinces have quite wider administration district and so greater lane-kilometres. As a result, the road density in provinces is about two or three times as big as the one in metropolitan cities. Lastly, regarding the port-related variables (*RT*, *TEUp*, and *TEUr*), quite huge differences are shown between the four regions such as Busan, Incheon, Ulsan and Jeonnam, and the other regions.

Table 6-2 Correlation analysis of variables

	y	L.y	yt	ngd	Sk	Sh	rd	RT	TEUp	TEUr
y	1.0000									
L.y	0.9960	1.0000								
yt	0.3228	0.3263	1.0000							
ngd	-0.0030	-0.0002	-0.0233	1.0000						
Sk	0.3544	0.3388	0.0282	0.0666	1.0000					
Sh	0.1325	0.1559	0.0657	0.0677	-0.2186	1.0000				
rd	0.1271	0.1247	-0.1496	-0.0664	0.0528	-0.2904	1.0000			
RT	0.4063	0.4031	0.6430	-0.0691	0.2728	-0.1524	-0.0570	1.0000		
TEUp	-0.0761	-0.0722	0.4402	-0.1089	-0.0326	0.1066	-0.2183	0.6781	1.0000	
TEUr	-0.0609	-0.0555	0.4531	-0.1114	-0.0342	0.1030	-0.2040	0.6731	0.9710	1.0000

Note: observations are 332, the critical value at the 5% significance in the two-tailed correlation test with 330 degrees of freedom (DF) is between 0.1129 with 300 DF and 0.1046 with 350 DF.

[85] The road density is more generally measured by lane-kilometres per unit area in the transportation studies. However, this study applies the road density measured by lane-kilometres per worker for the roads with four or more round trips due to several reasons as below;

- Consistency with other control variables as a per worker variable such as the GVA per worker.
- Stronger correlation with the dependent variable of the GVA per worker.
- Better fit of the regression model in terms of R-square.

6.2.3 Relationships between variables

Table 6-2 shows the results of the correlation analysis between 10 variables with the 332 observations. The critical value at the 5% significance in the two-tailed test with 330 degrees of freedom is between 0.1129 with 300 degrees of freedom and 0.1046 with 350 degrees of freedom.

From the table, it can be said that the regional GVA per worker has the positive correlation with almost variables; especially, the regional GVA per work in the previous year (*L.y*), the port cargo traffics measured by revenue tonne (*RT*), the ratio of income invested in the physical capital (*Sk*), and the regional GVA per worker in transportation (*yt*). As well, the ratio of income invested in the human capital (*Sh*) and the lane-kilometres per worker (rd) are positively correlated with the regional GVA per worker. Meanwhile, the regional GVA per worker is not correlated three other variables; the sum of the growth rate of population and the capital depreciation ratio (*ngd*), the container traffics of port (*TEUp*) and of region (*TEUr*) measured by TEU.

These statistics can be understood to conform to the general relationship between variables in the applied economic studies. Meanwhile, the results with regard to the port cargo traffics are somewhat inconsistent with the ones in the previous port studies (Shan et al., 2014, Park and Seo, 2016), which show that the growth of a regional economy has generally the positive correlation with port cargo traffics measured by *TEUp* and *TEUr*. However, the results that the positive correlation of the port traffics by RT but none correlation of the container traffics can be understood not to be inconsistent with the previous results if considering the cargo composition of major ports in South Korea. As discussed in chapter 7, port container traffics generated even in the capital area are concentrated to three major ports; Busan, Gwangyang, and Incheon. In addition, this understanding can be supported by the fact that port cargo traffics both by RT and by TEU are strongly correlated with the regional GVA per worker in transportation.

6.2.4 Summary

This study briefly discussed the relationship between the variables as well as the mean and the distribution of the variables by region. Among the port-related variables, it was clear that the variable measured by RT is strongly correlated with the GVA per worker. Based on the above results, this study introduces how to test the statistical relationship between the independent variables and the dependent variable from the next section.

6.3 Test for the Data

6.3.1 Tests for stationarity

The empirical analysis in econometrics generally starts from testing for stationarity of data sets; how to test depends on the type of data set (Frees, 2004). Focused on panel data, the longer the studied periods are, the more important the consideration for the stationarity in the sight of time-series is getting (Wooldridge, 2010).

Early econometrics for panel data put the cornerstone by resting on the short panel data which are usually consisted of thousands of individual or households (large N) with a few time survey accumulated (small T). The research used to be implemented at the level of microeconomics. Through the 1990s, according to Hsiao (2014), econometrics with panel data began to be applied in regional economic studies and macroeconomics as using panel data set with large N and moderate T, large T and large T, and moderate N and moderate T (16 regions and 26 years of panel data used in this study). These broadened types of panel data generally have the inherent drawback that panels are subject to spurious relationships due to non-stationarity of macroeconomic variables. According to Baltagi (2008, p.278), econometrics searched for the solution with regard to the stationarity of panel data in two directions. One approach is to use heterogeneous regressions (introducing the mean of a region) instead of accepting coefficient homogeneity (implicit assumption of pooled ordinary least square regressions); e.g. Pesaran et al. (1999). The other is to borrow the methods for time series analysis (estimators and tests) to panel data analysis in order to avoid or lessen non-stationarity; e.g. Kao et al. (1999) and Pedroni (2001).

These approaches supply the research direction for this study. The former is one of the regression models to analyse panel data, which is discussed in the next section. The latter is generally accepted as the procedure for testing stationarity of panel data, which is discussed in this section: unit roots test and co-integration test.

6.3.2 Unit roots test

6.3.2.1 Introduction

It is generally agreed that the models to test the unit roots for the panel data have developed together with or as following the spread of the panel data study to various applied research (Judson and Owen, 1999). In other words, the development path of unit root test is the procedure to mitigate strict assumptions as reflecting the difference with the feature of time series data (Choi, 2001).

In the early stage of unit root test, the methodologies were borrowed from the analysis for time series data, but after 2000, the ones applied for panel data were improved and developed (Choi, 2001).

According to Hsiao (2014), Levin and Lin (1993) and Levin et al. (2002), in the line of Dickey and Fuller (1979), Dickey and Fuller (1981)[86], respectively suggest the unit root test models based on the assumption that variables across individuals are homogenous. Im et al. (1997) propose the approach to take the average of separate unit root tests in order to relax the strong assumption of homogeneity. On the other hand, a few researchers such as Breitung and Meyer (1994) and Hadri (2000) suggest that the test for unit root can be applied partially to the stationary test, focused on the cross-sectional dependence.

6.3.2.2 Empirical application

This study briefly reviews the characteristics of the unit root test models based on the models adopted in Stata/IC 15.1, which is the version applied in the econometric analysis in this study. The Stata supplies 6 models for the unit root test for the panel data as shown in Table 6-3.

On one hand, the LLC model, the IPS model and the PP model can be evaluated to be in the line of the augmented Dickey and Fuller (ADF) model in the sight of the regression methodology. However, the IPS model and the PP model have some developed features in the aspects of alternative hypothesis and testing for unbalanced panel data.

Table 6-3 Comparison among unit roots test models

Model	H_0	H_1	Asymptotic assumption	Unbalanced panel	Non-stationary panel	Cross-sectional dependence
LLC	Unit root	No UR	Moderate T, large N	No	No	Demean
HT	Unit root	No UR	Fixed T, large N	No	Yes	Demean
Breitung	Unit root	No UR	Moderate T, Moderate N	No	Yes	Robust
IPS	Unit root	Some CS without UR	Large T, moderate N	Yes	Yes	Demean
PP	Unit root	Some CS without UR	Large T, large N	Yes	Yes	Demean
Hadri	No UR	Some CS with UR	Large T, large N	No	Yes (stationarity test)	Robust

Note: LLC; Levin-Lin-Chu, HT; Harris-Tzavalis, IPS; Im-Pesara-Shin, PP; Phillips-Perron, H_0; null hypothesis, H_1; alternative hypothesis, UR; unit root, CS; cross-sectional dependence, T; the number of time periods, N; the number of individuals and/or regions. Demean in Stata means that the statistics are not efficient due to the disturbance of the residuals if the cross-sectional dependence is present in the panel data. Robust in Stata indicates that the statistics are estimated as considering the disturbance of the residuals.
Source: compiled from Martins (2011), Stata's help of unit root test commands for panel data.

On another hand, the Breitung model and the Hadri model have the commonality in the sight that the cross-sectional dependence can briefly be analysed at the same time as the unit root test. Meanwhile,

[86] What the Dickey Fuller model is and what features the model have in the sight of statistics are beyond the scope of this study (See Dickey and Fuller (1979, 1981) for more specific information).

both models have the difference with regard to the null hypothesis, which is the presence of unit root in the former but nonexistence of unit root in the latter, and the alternative hypothesis, which is nonexistence of unit root in the former but is the presence of the cross-sectional dependence with a unit root. On the other hand, the HT model, which is for the panel with small T and large N, is recommended for the short panel data in microeconomics.

The panel data used in this study consist of several macroeconomic variables in 16 regions for 21 to 26 years; namely, it is unbalanced panel data as shown in Table 6-1. Furthermore, the variables in the Ulsan metropolitan city are observed from 1998. Considering the feature of the panel data[87] and the application of the model in previous port studies (Shan et al., 2014, Park and Seo, 2016), this study applies the IPS model for the unit root test.

6.3.2.3 The results

The results of the unit root tests are shown in Table 6-4. In this study, the unit root test was conducted on logarithmic variables rather than raw data. Meanwhile, in case of *ngd* which represents the sum of the growth rate of population and the capital depreciation rate, the unit root test was not performed successfully because a number of values under zero were lost as transferring the logarithmic variable. For this reason, this study transformed the variable of *ngd* to the variable of *lnngd* by equally adding 1 to each value and transferring the logarithmic variable (*lnngd*).

Almost variables reject the null hypothesis, which all panels have unit roots, at the confidence level of 95% and the road density rejects the null hypothesis at the confidence level of 90%. Meanwhile, the statistics by RT (*lnRT*) don't reject the null hypothesis at the confidence level of 90% but its p-value is just 0.1093 so that the unit root of *lnRT* can be interpreted not to be serious.

This study conducts the test of cross-sectional co-integration in the next part considering the alternative hypothesis of the IPS model.

Table 6-4 Unit root test for dependent and independent variables (IPS)

Variable	lny	lnngd	lnSk	lnSh	lnrd	lnRT	lnTEUp	lnTEUr
W-t-var	-2.3913	-2.8251	-2.8927	-1.9691	-1.3522	-1.2303	-7.5357	-5.0488
p-value	0.0084	0.0024	0.0019	0.0245	0.0881	0.1093	0.0000	0.0000

Note: H_o: panels have a unit root, H_1: at least a fraction of the series is stationary.

[87] The growth rate of population is observed since 1993 and the ratio of income invested in physical capital is observed since 1995. By this reason, both observation and degree of freedom can't help be lessened in order to apply the model which requests balanced panel data.

6.3.3 Co-integration test

6.3.3.1 Introduction

Like the unit root tests for the panel data, the co-integration tests have been developed in order to obtain more powerful tests through the same path; borrowing the co-integration tests for individual time series to specifying the methodologies for the panel data. According to Baltagi (2008), the tests from the time series data analysis are evaluated to have low power in case of the short panel data with short T. The co-integration tests for the panel data can be classified into three strands: a residual-based approach, a likelihood-based approach and an error-correction-based approach.

In the line of the former strand, Kao et al. (1999) and Pedroni (2001) proposed residual-based co-integration tests for the panel data. The former proposed residual-based DF and ADF tests which are a test for the null hypothesis of no co-integration and is calculated from the fixed effects residuals. The latter proposed several tests for the null hypothesis of co-integration which allows for considerable heterogeneity among individuals.

Larsson et al. (2001) presented a likelihood-based (LR) co-integration test which allows for the heterogeneity of panels based on the average of the individual rank trace statistics developed by Johansen (1995). Groen and Kleibergen (2003) improve Larsson et al. (2001) by allowing cross-sectional correlation (Baltagi, 2008).

Westerlund (2007) proposes four cointegration tests by extending the model of Banerjee et al (1998). According to Martins (2011), these tests have the commonality in the point that they allow for a large degree of heterogeneity and are focused on the structural differences rather than the serial changes. These tests assess the null hypothesis that the error term is zero; namely, no cointegration (Baltagi, 2008).

This study applies the Westerlund model considering the characteristics[88] of the model. As well, the model is very helpful to understand the results in the efficient connectivity[89] with the unit root test. In the following sub-section, this study discusses how to implement the empirical application of the model focused on the syntax and command of the model in Stata.

[88] Westerlund (2007) insists that the model has better size accuracy and higher power compared to the residual-based model developed by Pedrodi (2004) through implementing Monte Carlo simulations. In addition, the model can apply the co-integration tests both over time and among regions. As a result, the model can check if and how much the panel data are stationary both with consideration of cross-sectional dependencies or not.

[89] This is quite important since the panel data used in this study is understood to have partially unit root in a few variables even though p-value of lnRT in the unit root test is not quite big.

6.3.3.2 Empirical application

The critical issue in the empirical application is how to set the command[90] or the options[91] in Stata. Firstly, the test requests more than two variables but don't supply any guideline about the number of variables. By this reason, this can't help depending on the previous studies; for example, two variables in Persyn and Westerlund (2008) and three variables in Martins (2011). Secondly, how many lags and leads are appropriate for the panel data. With regard to this, Stata gives some hints to set the number of lags and leads considering the observations of panels. Lastly, in the case of *lrwindow*, 2 or 3 are recommended[92].

In an empirical application, the first issue and the second one are keenly related to the size of the panel data; especially the number of observation in longitudinal aspect. After several simulation tests[93], this study applies the combination of two variables and 2 in *lags* and *leads* rather than one of three variables and 1 in *lags* and *leads*. On the other hand, this study tested all pairs of two variables in logarithmic form; complementarily level form in case that the logarithmic variable is not fit for the asymptotic assumption as shown in Appendix 5 (A.5.3.2 Co-integration test).

6.3.3.3 The results

The results of the co-integration test not to account for cross-sectional dependence are shown in Table 6-5. The test is implemented on the null hypothesis of non-existing co-integration.

---

[90] The command of the Westerlund model is 'xtwest' and the syntax is as below

xtwest *depvar indepvars* [*if*] [*in*], *lags(# [#]) leads(# [#]) lrwindow(#) [constant trend bootstrap(#) westerlund noisily mg]*.

[91] Each option has meanings as below (Stata/IC 13.1 help);

- Lags (# [#]) specify the number of lags to be included in the error-correction equations. If one number is specified, it determines a fixed number of lags, p. If numbers are specified, the Akaike information criterion (AIC) is used to an optimal lag length, p_i, for each separate time series, within the given limits.
- Leads (# [#]) specifies the number of leads to be included in the error-correction equations; this is similar to the lags() option.
- Lrwindow (#) sets the width of the Bartlett kernel window used in the semiparametric estimation of long-run variances.
- Constant adds a constant to the co-integration relationship.
- Trend allows for a deterministic trend in the cointegration relationship.
- Bootstrap (#) shows bootstrapped p-values for all four test statistics. These are robust in the presence of common factors in the time series. The argument determines the number of bootstrap replications. On Stata/IC, the number of replications must be smaller than 800.
- Westerlund replicates the tables in Westerlund (2007).
- Noisily shows the regressions for the separate series. If a range of lags or leads is given, only the regression chosen by the AIC is shown.

[92] In case of the panel data used in this study, there was little difference to set 2 and 3 in *lrwindow*. The case of 2 in *lrwindow* shows more power to reject the null hypothesis of no co-integration than others.

[93] Stata shows the notice that the observations are not sufficient and some observations are not fit to asymptotic assumption of the Westerlund model in case of the combinations of three variables and 2 in *lags* and *leads*.

Table 6-5 Results of co-integration test over time

Variables	statistics							
	G_t		G_a		P_t		P_a	
	Value	P-value	Value	P-value	Value	P-value	Value	P-value
y / ngd*	-4.095	0.000	-37.505	0.000	-8.490	0.482	-27.628	0.000
lny / lnSk	-2.780	0.017	-10.383	0.819	-4.317	1.000	-13.814	0.001
lny / lnSh	-3.010	0.001	-25.702	0.000	-6.292	0.994	-16.463	0.000
lny / lnrd	-3.733	0.000	-19.836	0.000	-6.843	0.970	-18.442	0.000
lny / lnRT	-2.028	0.912	-7.766	0.980	-4.357	0.999	-16.538	0.000
ngd / Sk*	-5.596	0.000	-8.972	0.961	-9.477	0.116	-13.575	0.001
ngd / Sh*	-3.609	0.000	-8.484	0.980	-12.388	0.000	-15.906	0.000
ngd / rd*	-4.038	0.000	-12.891	0.275	-16.943	0.000	-16.563	0.000
ngd / RT*	-3.800	0.000	-15.642	0.012	-16.456	0.000	-22.613	0.000
lnSk / lnSh	-7.649	0.000	-29.010	0.000	-19.905	0.000	-31.698	0.000
lnSk / lnrd	-7.492	0.000	-30.466	0.000	-18.855	0.000	-25.228	0.000
lnSk / lnRT	-9.686	0.000	-39.270	0.000	-23.934	0.000	-43.641	0.000
lnSh / lnrd	-3.123	0.000	-25.854	0.000	-11.796	0.000	-22.787	0.000
lnSh / lnRT	-3.813	0.000	-12.316	0.417	-8.268	0.071	-13.702	0.004
lnrd / lnRT	-3.555	0.000	-17.867	0.002	-11.999	0.000	-24.521	0.000

Note: superscript * means that level variable is applied instead of logarithmic form.
G statistics are the group mean statistics and P statistics are the panel statistics.
Subscript *a* indicates the statistics which are calibrated using T in case of G statistics and the cross-sectional average of the effective number of observations per individual in case of P statistics from the statistics with subscript *t*.

Table 6-6 Results of the co-integration test by cross-sections

Variables	statistics							
	G_t		G_a		P_t		P_a	
	Value	P-value	Value	P-value	Value	P-value	Value	P-value
y / ngd*	-2.334	0.564	-4.463	1.000	-5.682	0.999	-2.547	1.000
lny / lnSk	-2.074	0.925	-4.304	1.000	-2.663	1.000	-2.829	0.999
lny / lnSh	-2.104	0.902	-8.554	0.979	-5.487	1.000	-6.049	0.970
lny / lnrd	-2.851	0.009	-7.195	0.998	-6.115	0.996	-7.026	0.893
lny / lnRT	-1.505	1.000	-4.042	1.000	-2.378	1.000	-3.197	0.999
ngd / Sk*	-3.393	0.000	-3.500	1.000	-7.009	0.950	-7.376	0.845
ngd / Sh*	-2.423	0.390	-3.167	1.000	-9.509	0.113	-9.078	0.462
ngd / rd*	-2.574	0.153	-4.489	1.000	-13.091	0.000	-9.442	0.370
ngd / RT*	-2.736	0.035	-6.064	1.000	-12.483	0.000	-11.810	0.030
lnSk / lnSh	-5.430	0.000	-15.988	0.010	-16.372	0.000	-16.279	0.000
lnSk / lnrd	-5.646	0.000	-15.647	0.016	-14.850	0.000	-20.002	0.000
lnSk / lnRT	-5.926	0.000	-18.530	0.001	-13.701	0.000	-16.999	0.000
lnSh / lnrd	-2.545	0.190	-8.272	0.986	-9.679	0.080	-8.924	0.502
lnSh / lnRT	-2.684	0.098	-6.218	0.998	-6.274	0.799	-5.477	0.969
lnrd / lnRT	-2.393	0.456	-5.096	1.000	-9.579	0.002	-10.832	0.152

Note: same to the note in table 8-5.

The table suggests that almost pairs of variables strongly reject the null hypothesis that all panels take no co-integration. The result can be understood that all pairs of variables are strongly co-integrated considering the size of T (statistics P_a) but panels of some variables have heterogeneity among regions (statistics G_a). It means that the data are strongly stationary just like the results from the unit roots tests in the previous sub-section.

On the other hand, the results of the test considering cross-sectional dependence in Table 6-6 are quite different. At a glance, almost all statistics cannot reject the null hypothesis of no cointegration. The results can be evaluated that the panels of variables cannot show the strongly co-integrated relationship with the regional dependence considered. This indicates this study has to check the cross-sectional dependence introduced in the next sub-section before the jump to the conclusion that the panel data are nonstationary. It seems to be more rational to interpret the result as the stationary panel data in time-series with cross-sectional dependence.

*6.*3.4 Summary

From the previous tests, this study suggests the implications with regards to the stationarity of the panel data used in this study. First of all, the data are strongly stationary in the sight of the individual time series. Meanwhile, the data are moderately stationary in the case of port traffic by RT. Secondly, the units of variables can't be evaluated to be homogenous; some units show strongly the heterogeneity like the results from the contextual analysis and the shift-share analysis in the previous chapters. Lastly, even though the panel data are stationary in the sight of time-series, units of some variables show the possibility that the panel data may have cross-regional dependence. As a result, this study should examine if the cross-sectional dependence is present while testing for the residuals in order to select the regression model and/or interpret the results from the regressions.

6.4 Preliminary Tests

6.4.1 Specification of the regression function

The regression function applied in this study is the empirical function mentioned in the previous research design. This is repeated as follows:

$$\ln y_{it} = \beta_0 + \beta_1 \ln(n_{it} + g_{it} + \delta_{it}) + \beta_2 \ln s_{k,it} + \beta_3 \ln s_{h,it} + \beta_4 \ln y_{it-1} + \beta_5 \ln rd_{it} + \gamma \ln X_{it} + u_{it} \qquad 8\text{-}1)$$

where, β_0; intercept, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \gamma$; coefficients, X_{it}; port related variable, u_{it}; the region-specific error term.

Based on this regression function, this study specifies the five types of regression models by adding a port variable to the control variables[94]. The regression function is in the same line as the previous port studies.

On the other hand, this study has the additional analyses that the sub-period analyses and the sub-region analyses are conducted based on the fundamental analysis. These additional approaches are basically applied as considering the relationship between the port traffics and the economic growth as shown in Figure 6-1. The two way scatters of port traffics (5 and 6) raise the doubt if it is proper to estimate a single coefficient for the whole data. The two graphs show that the values of the port traffics have the different statistical relationship with the growth of regional economies (y). At a glance, it is not clear that the layers are due to the longitudinal changes or the cross-sectional disparity so that this study designed to conduct both the sub-period analysis and the sub-region analysis. In this point, this study has quite unique originality compared to the previous studies that estimate the single coefficient of port-related variables with the whole panel data of Shan et al. (2014) and Park and Seo (2016).

For the sub-period analysis, three sub-periods[95]; 1994 to 2000, 2001 to 2008, and 2009 to 2015, are applied in order to examine how the coefficients of port-related variables have changed over time. This study applies three sub-periods since they can reconcile between the goal that the more sub-periods can show the trends over time better and the restriction that each sub-period analysis has

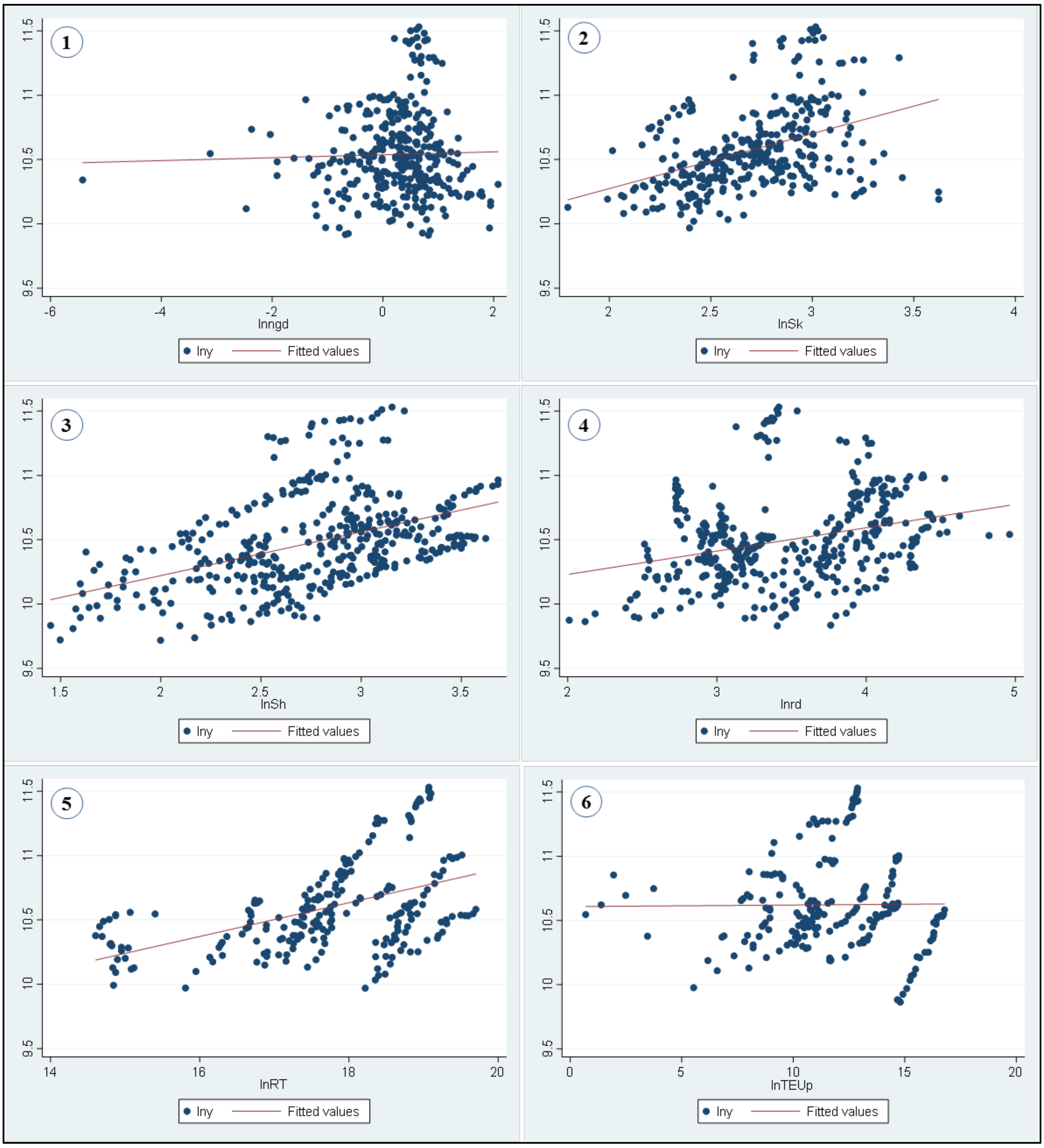
[94] Control variables are $\ln(n_{it} + g_{it} + \delta_{it})$, $\ln s_{k,it}$, $\ln s_{h,it}$, $\ln y_{it-1}$, $\ln rd_{it}$ and explanatory variables are $\ln RT$, $\ln TEUp$, $\ln TEUr$, and $\ln RT$ and *ConP*; a dummy variable which means presence of container dedicated facilities.

- Model 1; only with control variables.
- Model 2; with control variables and $\ln RT$.
- Model 3; with control variables and $\ln TEUp$.
- Model 4; with control variables and $\ln TEUr$.
- Model 5; with control variables and $\ln RT$ and *ConP*.

[95] This study analyses the data after 1994 in order to avoid the bias from the panel data set because some variables are gathered from 1994 or 1995 as shown in descriptive analysis in the previous sub-section.

enough observations for efficient estimation. In addition, with regard to sub-region analysis, the 80 million RT and the 100 thousand TEUs are applied for classifying a large port[96]. In practice, the former is a kind of the criteria to separate major ports from others and the latter is the one to classify the ports with container dedicated ports from the others.

Figure 6-1 Two-way scatters between independent variables and dependent variable



[96] The criteria to dividing the regions with large ports and the regions without large ports are decided considering two goals; 80 million RT is reasonable in the sight that it separates four major ports from the others and allocates the observations similarily between two sub-regions. Meanwhile, 100 thousand TEUs plays a same role as the reasonable criteria just like 80 million RT.

6.4.2 Selection of regression model

The theoretical studies have improved methodologies with regard to estimating parameters as well as testing the stationarity of the varied panel data. The models to estimate the parameters are fundamentally based on different rationales with regard to minimizing the bias (see Hsiao (2014)). In statistical theory, the various approaches rooted in the three models are presented while mitigating the assumptions needed to estimate the parameters and/or related to the residuals (Hsiao, 2014). Notwithstanding, a number of the applied research studies are still depending on three simplest linear models: the Pooled Ordinary Least Square (POLS) model, the fixed effect (FE) model, and the random effect (RE) model (Hamilton, 2012).[97]

On the other hand, in the case of applied research, the various approaches based on the fixed effect model, which takes individual or regional averages into account, are widely applied due to the feature that the panels have the inherent heterogeneity between persons, individuals, and regions (Asteriou and Hall, 2015). The preceding port studies follow the strand (Shan et al., 2014, Park and Seo, 2016). Despite this tendency, this study followed the general procedure to select the regression model among the three models of POLS, FE and RE.[98]

6.4.2.1 Test for the FE model vs the POLS model

Figure 6-2 shows the result of the regression analysis by using the FE model with the Model 2 applied. In addition, the note shows how to understand the results of the regression analysis with Stata.

Among the various statistics, it is the statistic of the F-test denoted by 10 in Figure 6-2 that is the critical criterion to determine which model is more appropriate between the FE model and the POLS model (Hamilton, 2012). The result, which tests the null hypothesis that all regional-specific errors are equal to zero, implies that the fixed effects are statistically superior to the POLS model and the regional specific constant is not equal to zero. As well, it can be interpreted that the panels are not homogenous by region (Hsiao, 2014). This result is quite consistent with the implications from the shift-share analysis in the previous chapter.

---

[97] Three models have different features with regard to the coefficients due to different assumptions.

- The pooled OLS model specifies constant coefficients of independent variables which are invariant over time and across individuals; $y_{it} = \alpha + \mathrm{x}_{it}' \beta + u_{it}$. As a result, this model is the most restrictive panel data model and is not applied much in the literature.
- The fixed effects model allows the individual-specific effects $\alpha_i$as intercepts to be correlated with the regressors x; $y_{it} = \alpha_i + \mathrm{x}_{it}' \beta + u_{it}$, where, $\hat{\alpha}_i = \bar{y}_i - \bar{\mathrm{x}}_i'\hat{\beta}$.
- The random effects model assumes that the individual-specific effects α_i as a part of error term which are distributed independently of the regressors x. So, each individual has the same parameters; $y_{it} = \mathrm{x}_{it}' \beta + (\alpha_i + e_{it})$, where a composite error term $\varepsilon_{it} = \alpha_i + e_{it}$.

[98] The preliminary tests in this sub-section are conducted by applying the Model 2 in which lnRT as an explanatory variable is added.

Figure 6-2 Result of estimating the parameters with the FE model applied

```
. xtreg lny lnngd lnSk lnSh L.lny lnrd lnRT, fe

Fixed-effects (within) regression               Number of obs      =       213
Group variable: ID                              Number of groups   =        11

①R-sq:                                          Obs per group:
     within  = 0.9769                                         min =        15
     between = 0.9933                                         avg =      19.4
     overall = 0.9819                                         max =        21

                                                F(6,196)           =   1378.45
②corr(u_i, Xb)  = 0.6593                      ③Prob > F           =    0.0000

------------------------------------------------------------------------------
         lny |  ④Coef.   Std. Err.    ⑤t  ⑥P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0029453   .0036759    -0.80   0.424    -.0101947    .0043041
        lnSk |   .0290111   .0145668     1.99   0.048     .0002833    .0577388
        lnSh |   .0565004   .0220882     2.56   0.011     .0129393    .1000614
             |
         lny |
         L1. |   .8175619   .0355638    22.99   0.000      .747425    .8876988
             |
        lnrd |    .015305   .0210111     0.73   0.467    -.0261319    .0567419
        lnRT |   .0179165   .0119557     1.50   0.136    -.0056619    .0414949
       _cons |   1.353233   .2910208     4.65   0.000      .779299    1.927167
-------------+----------------------------------------------------------------
   ⑦ sigma_u |  .04951865
   ⑧ sigma_e |  .03132909
   ⑨     rho |  .71414567   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(10, 196) = 3.45                   ⑩Prob > F = 0.0003
```

Note: 1. The R-square is an indicator to show how well the estimates of the regression model explain the changes in the observations. This is calculated as the sum of squares divided by the total sum of squares.[99]
2. The result of the correlation between regional-specific error (u_i) and fitted values of dependent variable shows how strongly the former is correlated with the latter.
3. The result of F-test, which examines whether all the coefficients in the model are equal to zero, shows the goodness of the model at the confidence level of 95% if the figure is smaller than 0.05.
4. Coefficients indicate how much the dependent variable changes when the independent variable increases by one unit under the assumption the other independent variables stay consistently.
5. The values indicate the results of the t-test of the null hypothesis that each coefficient is the same as zero. To reject the null hypothesis, the t-values in the two-tailed test have to be higher than 1.96 at the confidence level of 95%. When the t-value that the ratio of the coefficient to the standard error is higher, this means that the relevance of the variable is stronger.
6. The p-value indicates the probability associated with exceeding the absolute t-value. The p-values indicate the probability that the null hypothesis is true and the significance level. To reject the null hypothesis, the p-values in the two-tailed test have to be lower than 0.05 at the confidence level of 95%.
7. Sigma *u* means the standard distribution of residuals within group u_i.
8. Sigma *e* means the standard distribution of residuals (overall error term) e_i.
9. $rho = ((sigma\ u)^2)/((sigma\ u)^2 + (sigma)^2)$. The *rho* means how big variance is due to the differences across panels; so-called the intra-class correlation.
10. The result of F-test, which examines whether all regional specific errors are equal to zero, shows if the fixed effects are statistically significant.
Source: Gujarati and Porter (1999) and Hamilton (2012)

---

[99] The FE effect model supplies three types of R-squares as below.
- The 'overall' means how much the estimates explain the changes of each observations.
- The 'within' indicates how much the estimates describe the changes of panels over time within a region.
- The 'between' means how much the estimates cover the difference between regions.

Figure 6-3 Result of the test for the RE model versus the POLS model

```
. quietly xtreg lny lnngd lnSk lnSh L.lny lnrd lnRT, re

. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        lny[ID,t] = Xb + u[ID] + e[ID,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                     lny |   .1173665       .3425879
                       e |   .0009815       .0313291
                       u |   .0000726       .0085203

        Test:   Var(u) = 0
                             chibar2(01) =     0.03
                          Prob > chibar2 =   0.4277
```

6.4.2.2 Test for the RE model vs the POLS model

As the second step, the RE model is necessary to be compared to the POLS model. In order to do so, the Breusch and Pagan Lagrangian Multiplier (LM) test is applied the most generally in econometrics (Baltagi, 2008). Figure 6-3 shows the result of Breusch and Pagan LM test. The p-value of 0.4277 cannot reject the null hypothesis, in which the variation of regional-specific errors is equal to zero, at the confidence level of 95% and even of 90%. In other words, the RE model is not superior to the POLS model.

6.4.2.3 Test for the FE model versus the RE model

As the last step, the comparison between the FE model and the RE model is required for the model selection. With regard to this comparison, the Hausman test as shown in Figure 6-4 is generally applied in econometrics (Baltagi, 2008). The result shows that the null hypothesis, which means that the RE model is more appropriate than the FE model, is strongly rejected at the confidence level of 95%; the p-value is 0.0016. In other words, the FE model is superior to the RE model for this study.

6.4.2.4 Summary

Through three different methods, this study makes it clear which model is the most appropriate for the regression analysis. The result that the FE model is the most appropriate for this study is quite reasonable considering the quite different features of the 16 regional economies. Based on the results, in the next sub-section, this study examines the statistical features and the goodness of fit, which are the criteria to decide whether the model is appropriate for the empirical analysis.

Figure 6-4 Result of the test for the RE model versus the FE model

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
       lnngd |   -.0029453    -.0038446        .0008993        .0011335
        lnSk |    .0290111     .0375258       -.0085147        .0078599
        lnSh |    .0565004    -.0188127         .075313        .0202344
         lny |
         L1. |    .8175619      .967707       -.1501451         .032503
        lnrd |     .015305    -.0013876        .0166926        .0192769
        lnRT |    .0179165    -.0022952        .0202117        .0110556
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       21.36
                Prob>chi2 =      0.0016
                (V_b-V_B is not positive definite)
```

6.4.3 Tests for the regression model

According to Gujarati and Porter (1999), Harvey (1981) suggested five features[101] required for a good regression model. In spite of the theoretical discussions about the features of a good model, most empirical studies focus on the goodness of fit and the theoretical consistency to determine whether a model is adequate. This study also evaluates the adequacy of the model in the sights of the goodness of fit and the theoretical consistency.

Figure 6-5 Goodness of fit with R-squared and adjusted R-squared

```
. display "R-squared (overall) =" 0.9819
R-squared (overall) =.9819

. display "Adj R-squared (overall) =" 1-(1-0.9818)*(212/208)
Adj R-squared (overall) =.98145
```

[101] Five requirements:
- Parsimony: the model should be simple through abstracting or simplifying of the relationship among various factors because the model cannot fully explain the reality.
- Identifiability: unique parameter or one estimate for one parameter in the given data.
- Goodness of fit: well explaining the changes of the dependent variable in the relation to the explanatory variables.
- Theoretical consistency: conforming the sign of the coefficients etc. to the economic theory.
- Predictive power: well predicting future values of the dependent variable based on the past.

6.4.3.1 Goodness of fit

This study checks the goodness of fit with three simple statistics such as R-squared, adjusted R-squared, and F-test, even though many tests have been suggested (Gujarati and Porter, 1999). In the sight of the R-squared, the regression model can be said to have such a statistically strong power. As shown in Figure 6-2, the R-squared is around or greater than 0.98; especially, the value of 'between' is relatively great; namely, 0.9933. It can be inferred that the independent variables explain the changes in the dependent variable quite well. In addition, the adjusted R-squared is calculated from the R-squared with the degree of freedom considered. The result in Figure 6-5 suggests that the regression model has the considerably high goodness of fit even though the adjusted R-squared is slightly lower than the R-squared. Lastly, the statistic of the F-test in Figure 6-2 is 0.0003 so that the null hypothesis is rejected.

6.4.3.2 Theoretical consistency

In the sight of economic theories, it should be considered to check if the sign of the coefficients, which indicates the relationship between the independent variable and the dependent variable, conforms to general theories. In general, it is known that the population growth is negatively related to the economic growth measured by the capital stock per capita[102], and the ratio of income invested in the physical capital and the ratio of income invested in the human capital are known to have a positive relationship with the economic growth (Mankiw et al., 1992). As well, a huge body of researchers suggest that the transport infrastructure such as road plays a significantly positive role in the regional economy (Crescenzi and Rodríguez-Pose, 2012).[103] Based on these, the results are understood that the independent variables are in the consistent relationship with the dependent.

As well, it is helpful to understand the theoretical consistency by comparing with the results of previous studies with the similar regression model applied. On one hand, in the case of Shan et al. (2014), the initial GDP per capita and the consumer price index (CPI) are negatively related to the growth rate of GDP per capita. However, the other variables such as the ratio of income invested in education, the ratio of foreign direct investment to GDP, and the ratio of government expenditure to CDP have a positive relationship. As well, port cargo traffics are positively related to the dependent variable. On the other hand, in the case of Park and Seo (2016), the growth rate of the regional GDP per capita is positively related with the independent variables such as the ratio of income in the

[102] Higher population growth lowers income per capita because the stocked physical capital must be spread more thinly over more population of workers.

[103] The transport infrastructure has been suggested to bring the positive impacts through various effects: for example, improvement effect in productivity (Biehl, 1991), multiplier effects in investment flows as an unpaid factor of production function (Lewis, 1998), increasing personal welfare and generating environmental externality (Kessides, 1993), and increasing the accessibility to the potential market (Neibuhr, 2006).

physical capital, the ratio of income invested in the human capital, the effective ratio of capital depreciation, and port cargo traffics.

6.4.4.3 Summary

Through the goodness of fit and the theoretical consistency mentioned above, this study makes it clear that it is reasonable to apply the extended versions as well as the proposed model as it is to the subsequent discussion.

6.4.4 Test for the multi-collinearity

6.4.4.1 Introduction

As the multiple regression model, it can retain some problems with regard to the requirements for the best linear unbiased estimator (BLUE) even if it is appropriately specified (Gujarati and Porter, 1999). For this reason, all empirical analyses are required to check if the model keeps the assumptions related to the variables and the residuals in order to improve the efficiency of the estimation. The representative issue related to the form is the multicollinearity.[104]

The multicollinearity breaks the assumption of the multiple regression model that the explanatory variables are independent of each other; namely, the covariance of the two explanatory is equal to zero (Gujarati and Porter, 1999). It occurs due to the misspecification of the regression model such as setting the same or related variables; however, the representative reason is that more than two explanatory variables are correlated (Gujarati, 2009). The presence of the multi-collinearity causes the greater standard errors and the lower power of the model. Even the extreme multi-collinearity (so long as it is not perfect) does not violate the OLS assumptions; namely, the OLS estimates are still unbiased and the best linear unbiased estimators (BLUE) but inefficient (Gujarati and Porter, 1999). In other words, the confidence intervals for coefficients tend to be very wide and the t-statistics tend to be very small if the multicollinearity is quite strong.

Multicollinearity in multiple regression model is agreed to be a matter of degree. As well, there is no agreed methodology the check whether the multicollinearity is a problem or not (Wooldridge, 2015). According to Gujarati and Porter (1999),[105] the multicollinearity is not a test, but rather a measure of the degree, with several methods used. This study applies the variance inflation factor (VIF) which is widely used in empirical studies considering the VIF supplies the value for examining the degree of multicollinearity.

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[104] The issues related to the residuals are discussed in the next sub-section (8.4.5 Test for the residuals).
[105] Comparing the R-squared and the t-test statistics, pairwise correlation among independent variables, partial correlation among independent variables, auxiliary regression, and the VIF.

6.4.4.2 Result of the Variance Inflation Factor

The VIF is calculated for each predictor by doing a linear regression of the predictor on all the other predictors and then obtaining the R^2 from the regressions (Gujarati and Porter, 1999). The VIF is just $1/(1-R^2)$. Meanwhile, the VIF is so-called a 'rule of thumb' technique; it creates a number but does not have suggested theoretical criteria to clarify whether a VIF measurement of a certain size is a cause for concern to a statistical certainty. The usual rule of thumb is that any variable with a VIF greater than 10 is probably a concern and if the average VIF is 'substantially greater than 1.0, there may be one or more collinear independent variables (O'Brien, 2007).

The result of the VIF test, where *lnRT, lnTEUp* and *lnTEUr* are applied as an explanatory variable, is shown in Table 6-7. At the bottom of the table, the VIF measurements of six independent variables and the mean VIF of 2.18 suggests that the regression model have some multi-collinearity; however, it is not as severe as the model is concerned (O'Brien, 2007).[106] In addition, the results of the VIF test, in which the other explanatory variables of *lnTEUp* and *lnTEUr* are applied, are even better than the result of *lnRT*. As a result, it can be concluded that the regression models with *lnRT*, *lnTEUp* and *lnTEUr* have the multicollinearity but is good enough to apply the econometric analysis.

6.4.4.3 Summary

This study applies the presented regression model based on the evaluation that the multi-collinearity of the transportation variables are not severe according to the rule of thumb. In the next sub-section, this study continues to check the residuals-related issues.

Table 6-7 Result of the variance inflation factor (VIF)

Control variables & lnRT

. vif

Variable	VIF	1/VIF
lnRT	3.50	0.285936
lny		
L1.	2.63	0.380845
lnrd	2.31	0.433818
lnSk	1.89	0.528421
lnSh	1.41	0.708358
lnngd	1.38	0.726274
Mean VIF	2.18	

Control variables & lnTEUp

. vif

Variable	VIF	1/VIF
lny		
L1.	2.01	0.496357
lnrd	1.88	0.531959
lnSk	1.79	0.558256
lnTEUp	1.75	0.572889
lnSh	1.25	0.801395
lnngd	1.14	0.877414
Mean VIF	1.64	

Control variables & lnTEUr

. vif

Variable	VIF	1/VIF
lny		
L1.	2.03	0.492621
lnSk	1.79	0.558619
lnrd	1.75	0.571985
lnTEUr	1.67	0.597945
lnSh	1.28	0.779956
lnngd	1.13	0.882387
Mean VIF	1.61	

[106] The VIF measurement of around two or three is regarded as a weak degree of the multicollinearity.

6.4.5 Tests for the error term

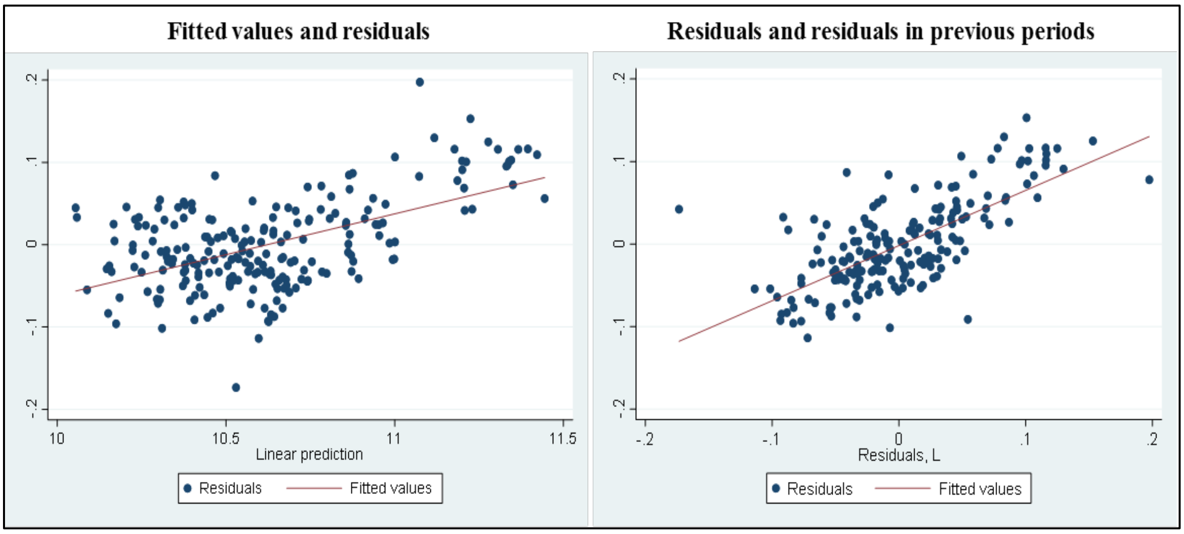
6.4.5.1 Introduction

The classical linear regression model is based on the assumption that the error term has the identical and independent distribution (Gujarati and Porter, 1999). In the case of the panel data, two assumptions are related to three different types; the heteroscedasticity, the serial correlation, and the cross-sectional dependence (Baltagi, 2008). Therefore, this study conducts three tests related to the residuals in order to determine if a linear regression model is efficient statistically.[107]

6.4.5.2 Test for the heteroscedasticity

The assumption that the error term has uniform distribution is necessary in order that the estimators in the linear regression model are both unbiased and efficient. In the empirical econometric studies, various methods such as scatter plot of residuals and fitted values, the Park test, the Glejser test, the modified Wald test, and the White test etc., are generally applied to examine whether the error term violates the homoskedasticity assumption (Gujarati and Porter, 1999, Baltagi, 2008). In order to examine the assumption of the homoscedasticity, this study applies the scatter plot and the modified Wald test as considering that it is viable even when the assumption of normality is violated (Baum, 2001) and that it is the default command in Stata. Figure 6-6 shows the relationship between the fitted values and the residuals and between the residuals and the residuals in the previous period. The left-side graph show that the residuals have the upward slope as the fitted value increases.

Figure 6-6 Scatter plot of fitted values and residuals (the homoskedasticity test)



[107] This study focuses on testing whether two assumptions related to the error term are kept in the regression model rather than discussing the features and the statistical effects of the assumptions and the methodologies to correct the problems with regard to the heteroscedasticity, the serial correlation and the cross-sectional dependence (See Gujarati and Porter (1999) for the detailed).

Figure 6-7 Result of the modified Wald test (the heteroscedasticity test)

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (11)  =    4093.64
Prob>chi2 =      0.0000
```

The result of the modified Wald test, which is under the null hypothesis that the residuals are in the homoscedasticity, are as shown in Figure 6-7. The result strongly rejects the null hypothesis at the confidence level of 100%; namely, the residuals do not have the identical distribution. From the results of the scatter plot and the modified Wald test, it is clear that the regression model needs to be corrected as reflecting the heteroskedasticity of the error term.

6.4.5.3 Test for the serial correlation

The other assumption is that the error terms are independent of each other. In the case of the panel data, the assumption has two different aspects; the serially independent and the cross-sectional independent (Baltagi, 2008). In order to see if the residuals are serially independent, the empirical research usually applies several methods such as the scatter plot, the Durbin-Watson D scale, the Runs test, and the Wooldridge test etc. (Gujarati and Porter, 1999, Wooldridge, 2010).

This study applies the scatter plot and the Wooldridge test, which is the default command in Stata, due to the feature that the test requires relatively few assumptions and is easy to implement (Drukker, 2003). The right-side scatter plot in Figure 6-6 shows how strong the residuals (Y-axis) correlates with the ones in the previous year (X-axis). At a glance, it is clear that the residuals are positively correlated. As well, the result of the Wooldridge test strongly supports that the suspicion based on the scatter plot is reasonable. The result shown in Figure 6-8 suggests that the null hypothesis of no autocorrelation is rejected at the confidence level of 95% and even of 99%.

Figure 6-8 Result of the Wooldridge test for autocorrelation

```
. xtserial lny lnngd lnSk lnSh lnrd lnRT

Wooldridge test for autocorrelation in panel data
H0: no first order autocorrelation
    F(  1,      10) =     48.574
           Prob > F =      0.0000
```

From the results of the scatter plot and the Wooldridge test, it can be concluded that the residuals do not keep the assumption of the independent distribution. As a result, this study has to consider how the regression model can be corrected to mitigate the assumption that the residuals are serially independent.

6.4.5.4 Test for the cross-sectional dependence

The other issue related to the second assumption is that the residuals have the cross-sectional dependent distribution in the case of the panel data (Baltagi, 2008). On the other hand, this disturbance had been a major issue in dealing with social data even before the panel data began to be used explosively in the social sciences (Sarafidis and Wansbeek, 2012).[108] A growing body of research put interests on the reasons for the cross-sectional dependence and propose the methodology to correct the inefficiency in the estimation of parameters (De Hoyos and Sarafidis, 2006).[109]

Despite the vivid theoretical discussion of interdependence and the diverse diagnostic methods, the applied research is likely to rely on methods provided by statistical programs (De Hoyos and Sarafidis, 2006). In this study, the test for the cross-sectional dependence is conducted with the commands of *xttest2*[110] and *xtcsd*[111], which are the most popular commands in Stata (Hamilton, 2012).

---

[108] The interdependence among individuals and regions is familiar issue in the social science since the 1930s. According to cite, Neprash (1934, p. 168) asserts that 'the correlation of spatially distributed variables must be accepted with severe limitations of interpretation. The data involved violate two important conditions of sound application of correlation and sample techniques.'

[109] The cross-sectional dependence may result from the presence of common shocks and unobserved components that are part of the error term and the idiosyncratic pair-wise dependence in the error terms. One reason for this may be the ever-increasing economic and financial integration of countries and regions.

[110] The *xttest2* is for use with cross-section time-series data, following use of *xtreg, fe, xtgls* or *ivreg2*, and requiring prior use of *tsset*. The *xttest2* calculates the Breusch-Pagan statistic for cross-sectional independence in the residuals of a fixed effect regression model, following Greene (2000, p. 601*). xtreg, fe* estimates this model assuming independence of the errors (Stata/IC 13.1 help).

[111] The *xtcsd* is a post-estimation command for testing for cross-sectional dependence in the FE model and the RE model for the panel data. A standard assumption in panel data models (*xtreg*) is that the error terms are independent across cross-sections. This assumption is employed for identification purposes rather than descriptive accuracy. In the context of large T and small N, the LM test statistic proposed by Breusch and Pagan (1980) can be used to test for cross-sectional dependence (*xttest2*). However, in most cases, cross-sectional time-series data sets come in the form of small T and large N. In this case the Breusch-Pagan test is not valid (Stata/IC 13.1 help).

The *xtcsd* test the hypothesis of cross-sectional independence in panel data models with small T and large N by implementing two semi-parametric tests proposed by Friedman (1937) and Frees (1995, 2004), as well as the parametric testing procedure proposed by Pesaran (2004). The xtcsd with option pesaran can handle balanced as well as unbalanced panels. One of method's options pesaran, friedman or frees must be specified (continued in the next page).

- pesaran: testing for cross-sectional dependence following the methods shown in Pesaran (2004). Pesaran's statistic follows a standard normal distribution and it is able to handle balanced and unbalanced panels.
- friedman: testing for cross-sectional dependence using Friedman's chi-square distributed statistic. Friedman's test uses only the observations available for all cross-sectional units.
- frees: testing for cross-sectional dependence using Frees' Q distribution (T-asymptotically distributed). For unbalanced panels Frees' test uses only the observations available for all cross-sectional units.

Figure 6-9 Results of various tests for the cross-sectional dependence

```
. xtcsd, pesaran abs

Pesaran's test of cross sectional independence =    11.026, Pr = 0.0000

Average absolute value of the off-diagonal elements =     0.367
```

```
. xtcsd, frees

  Frees' test of cross sectional independence =     1.365
|--------------------------------------------------------|
  Critical values from Frees' Q distribution
                     alpha = 0.10 :   0.2828
                     alpha = 0.05 :   0.3826
                     alpha = 0.01 :   0.5811
```

```
. xtcsd, friedman

Friedman's test of cross sectional independence =    56.806, Pr = 0.0000
```

The results of testing for the cross-sectional dependence are shown in Figure 6-9. The three tests which are supplied in Stata show that the panel data does not meet the cross-sectional independence assumption. Firstly, Pesarans's test suggests that the p-value is 0.0000 so that the null hypothesis of cross-sectional independence is strongly rejected. As well, the value of Free's test (1.365) is over the critical value at the confidence level of 99% (0.5811). Lastly, the Friedman's teat also supply the same results as the former. In conclusion, the panel data do not meet the independence assumption.

6.4.5.5 Summary

This study confirms that the error term in the linear regression model violates the assumptions of the homoscedasticity and the independence. This statistically means that the coefficients of the estimates by the linear regression model may not be biased but be inefficient (Wooldridge, 2010, De Hoyos and Sarafidis, 2006). In this case, the procedure to correct three types of disturbance: namely, the heteroskedasticity, the serial correlation and the cross-sectional dependence, is required. This study introduces how to correct the disturbance of the residuals focused on the applied research but not the theoretical discussion in the next sub-section.

6.4.6 Selection of corrected regression model

6.4.6.1 Theoretical evolution

The theoretical discussion on how to correct disturbances in the residual error has become an important issue of econometrics (Wooldridge, 2010). Even though a number of researchers suggest the treatments for the disturbance, these discussions can be classified into two strands. One approach is to correct the disturbance by estimating parameters after modifying the variables and/or changing the regression model. The other is to reflect the disturbance in the residuals by correcting the standard deviation of the error term (De Hoyos and Sarafidis, 2006).

The former approach is generally based on the assumption that the disturbance in the error term is caused by the common factors that are correlated with the included regressors but not observed by the linear regression model such as the FE model and the RE model (Wooldridge, 2010).[112] In this case, the coefficients estimated with the FE model and the RE model cannot be an unbiased estimator. Accordingly, various evolved regression models have been proposed in order to clarify unobserved common components as considering the type of the disturbance in the residuals (see Wooldridge (2010), Baltagi (2008) for the detailed). On the other hand, the latter approach assumes that the disturbance occurs due to the presence of the unobserved common factors, which are not correlated with the included regressors (Wooldridge, 2010). In this case, the coefficients estimated with the FE model and the RE model are unbiased estimates but are not efficient. As a result, this strand has the feature that the efforts to correcting the disturbance are put on estimating the standard distribution of the coefficients but not estimating of the coefficients (Baltagi, 2008).

In spite of these theoretical evolutions, the latter approach is more popularly applied in the empirical analysis in order to partially improve the inefficiency of the regression model (Gujarati and Porter, 1999, Stock and Watson, 2008). This is since it is theoretically possible to distinguish between the unobserved factors correlated with the included regressors and the ones not correlated with; however, in practice, it is almost impossible and not feasible (De Hoyos and Sarafidis, 2006). Therefore, in the fields of empirical studies, the disturbance of the error term is generally corrected by the approach of modifying estimating of the standard distribution of the error term (Hoechle, 2007). In this line, this study follows the latter approach, which is more popular in the empirical studies, in order to improve the efficiency of the regression model by mitigating the assumption related to the residuals (Stock and Watson, 2008). As well, this procedure is focused on conducting effectively with Stata.

6.4.6.2 Features of various models in Stata

In the empirical studies, a substantial discussion with regards to correcting the disturbance in the residuals is recommended to focus on the regression models provided by the statistic package (De Hoyos and Sarafidis, 2006). In the case of this study, how to correct the disturbance in the residuals needs to be considered in the boundary of the commands in Stata.

[112]The heteroskedasticity can be corrected by re-specifying the model or transforming the variables, and using Weighted Least Squares (WLS). The auto-correlation can be corrected by applying Generalized Least Squares (GLS) and estimating ρ estimator. The cross-sectional dependence can be corrected by applying the spatial approach and an instrumental variables (IV) type approach and

From this point of view, Figure 6-10 briefly shows the characteristics of the linear regression models for the panel data. Each command in the first column has the statistical characteristics, the extent to which the disturbance in the residuals can be corrected, and the constraints for applying the mode.

Figure 6-10 Comparison of the characteristics of commands for the panel data in Stata

Command	Option	Estimator	Corrected disturbance	Feasibility of the fixed effects	Notes
reg	robust, cluster ( )	OLS	robust: heteroscedastic cluster ( ): heteroscedastic, autocorrelated	No	
xtreg	fe, re robust, cluster ( )	Fixed-effects, GLS	robust: heteroscedastic cluster ( ): heteroscedastic, autocorrelated	Yes	
xtregar	fe, re		autocoreated with AR(1)[1]	Yes	
newey	lag ( )	OLS	heteroscedastic, autocorrelated of type of MA(q)[2]	No	
xtgls	panels ( ), corr ( )	FGLS	heteroscedastic, cross-sectionally correlated , auto-correlated of type AR(1)	No	N < T required for feasibility; tends to produce optimistic SE estimates
xtpcse	correlation ( )	OLS or Prais-Winsten regression	heteroscedastic, cross-sectionally correlated , auto-correlated of type AR(1)	No	large-scale panel regression takes a lot of time
xtscc	lag ( ), fe, re	OLS, Fixed effects, GLS	heteroscedastic, autocorrelated with MA(q)[2], cross-sectionally dependent	Yes	

NOTE: [1] AR(1) refers to first-order autoregression
[2] MA(q) denote autocorrelation of the moving average type with lag length q.
OLS stands for Ordinary Least Square.
GLS stands for Generalized Least Square.
FGLS stands for Feasible Generalized Least Square.
reg: fitting a model of depvar on indepvars using linear regression.
xtreg: fitting regression models to panel data. In particular, xtreg with the be option fits random-effects models by using the between regression estimator; with the fe option, it fits fixed-effects models (by using the within regression estimator); and with the re option, it fits random-effects models by using the GLS estimator (producing a matrix-weighted average of the between and within results).
xtregar: fitting cross-sectional time-series regression models when the disturbance term is first-order autoregressive. xtregar offers a within estimator for fixed-effects models and a GLS estimator for random-effects models.
newey: producing Newey-West standard errors for coefficients estimated by OLS regression. The error structure is assumed to be heteroskedastic and possibly autocorrelated up to some lag.
xtgls: fitting panel-data linear models by using feasible generalized least squares. This command allows estimation in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels.
xtpcse: calculating the panel-corrected standard error (PCSE) estimates for linear cross-sectional time-series models where the parameters are estimated by OLS or Prais-Winsten regression. When computing the standard errors and the variance-covariance estimates, xtpcse assumes that the disturbances are heteroskedastic and contemporaneously correlated across panels.
xtscc: producing Driscoll and Kraay (1998) standard errors for coefficients estimated by pooled OLS/WLS, fixed-effects (within), or GLS random effects regression.
Source: modified by the author from Hoechle (2007) and each reference in Stata help.

It is clear that each command is based on a different parameter estimator such as OLS, fixed-effect regression, GLS and feasible GLS. In addition, each command has the different composition out of three types of the disturbance in the residuals as the default or by selecting options. Specifically, the first four commands in Table 8-7 can only deal with one or two types of the disturbance but the last three commands supply the regression with three types of the disturbance corrected. In terms of the type of estimator, two commands of '*xtgls*' and '*xtpcse*' conduct to estimating the parameters with OLS and GLS respectively, but the command of '*xtscc*'[113] does so with three types of estimator applied. For this reason, this study corrects the disturbances in the residuals by applying the command of '*xtscc*'.

6.4.6.3 Summary

In this sub-section, this study introduces what the issues with regard to the variables and the residuals are and how the disturbances can be corrected in the empirical analysis. In addition, this study overviews the commands in Stata to correct the disturbance in the residuals focused on the regression model for the panel data. Lastly, this study introduces why this study selects the command '*xtscc*' in order to correct the model considering the three different disturbances in the residuals. In this line, this study continues to discuss the results of the parameter estimation with the command '*xtscc*' applied in the next section.

---

[113] The command 'xtscc' produces Driscoll and Kraay (1998) standard errors for coefficients estimated by the pooled OLS/WLS, fixed-effects (within), or GLS random effects regression (Stata help).

xtscc depvar [indepvars] [if] [in] [weight] [, options]

where, *depvar* is the dependent variable and *varlist* is an list of explanatory variables.

- *lag(#)* specifies the maximum lag to be considered in the autocorrelation structure. If you do not specify this option, a lag length of m(T)=floor[4(T/100)^(2/9)] is chosen.
- *fe* performs fixed-effects (within) regression with Driscoll-Kraay standard errors.
- *re* performs GLS random-effects (RE) regression with Driscoll-Kraay standard errors.
- *pooled* performs pooled OLS/WLS regression with Driscoll-Kraay standard errors.
- *noconstant*; see [R] estimation options.
- *ase* returns asymptotic Driscoll-Kraay standard errors. Standard errors that are computed this way might be slightly overoptimistic as they abstract from

6.5 Estimating Parameters

6.5.1 Introduction

As introduced in the model specification, this study conducts the empirical analysis at three different levels; namely, the overall analysis with the whole data in 16 regions for the studied period, the sub-period analysis, and the sub-region analysis. In addition, this study applies the command '*xtscc*', which is the fixed-effects estimator with the Discroll and Kraay standard errors reflected, into four different models at three different levels.[114] As discussed in the previous section, this study applies 80 million RT and 100 thousand TEUs as the criteria to divide two sub-regions 'with large ports' and 'without large ports'.

6.5.2 Overall analysis

The results of the overall analysis are shown in Table 6-8. This study discussed the goodness of fit and the theoretical consistency with the Model 2 applied in the previous section. In this section, based on the previous discussion, this study jumps to discussing the results of each model.

The results can be understood in the various sights with different statistics focused. First of all, at the level of the descriptive analysis, the table shows that the number of observations is different among three groups of the models: the control model (Model 1), the models with the explanatory variable

Table 6-8 Regression results for the whole cross-sectional time-series (1990-2015)

Period	Model	1 (C Vars)		2 (RT)		3 (TEUp)		4 (TEUr)		5 (RT, ConP)	
		Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
1990-2015	lnngd	-0.0019	0.6940	-0.0029	0.5750	-0.0019	0.6900	-0.0020	0.6650	-0.0030	0.5730
	lnSk	0.0300	0.2110	0.0290	0.2630	0.0425	0.1440	0.0463	0.1640	0.0308	0.2610
	lnSh	0.0645	0.0020	0.0565	0.0060	0.0843	0.0020	0.0862	0.0010	0.0557	0.0080
	L1.lny	0.8233	0.0000	0.8176	0.0000	0.7489	0.0000	0.7330	0.0000	0.8157	0.0000
	lnrd	0.0168	0.4720	0.0153	0.5490	0.0418	0.0970	0.0441	0.1020	0.0171	0.5030
	lnRT			0.0179	0.0050					0.0173	0.0050
	lnTEUp					0.0008	0.6020				
	lnTEUr							0.0020	0.4900		
	ConP									0.0042	0.4820
	cons.	1.5652	0.0000	1.3532	0.0010	2.1791	0.0000	2.3090	0.0000	1.3728	0.0010
	Obs.	316		213		175		175		213	
R-square	within	0.9763		0.9769		0.9651		0.9653		0.9769	

Note: Coef.; coefficient, C Vars; control variables, RT; control variables and lnRT, TEUp; control varialbes and lnTEUp, TEUr; control variables and lnTEUr, RT, Conp; control variables, lnRT and dummy variable of ConP.

[114] The tests for the residuals in the basic models such as Model 3 and Model 4 show the similar result with the one of the Model 2.

of *lnRT* (Model 2 and 5), and the models with the explanatory variable of *lnTEUp* and *lnTEUr* (Model 3 and 4). It suggests that there may be considerable heterogeneity with regard to the industrial structure in a regional economy: especially, the transport network as well as the port systems.[115] As well, this interpretation can be supported by the fact that the results of the F-test reject the null hypothesis of no regional difference at the confidence level of 95%, as shown in Appendix 5 (A.5.5 Results of estimating parameters).

Secondly, in the sight of R-square, the Model 2 and 5 have the somewhat higher goodness of fit than the control model (Model 1), whilst the Model 3 and 4 have slightly lower one than the control model.

Thirdly, at the level the coefficients of independent variables, the results suggest that Model 2 and 5 are relatively stable compared to the Model 3 and 4. On one hand, four independent variables excluding capital depreciation (*lnngd*) in the control model have positive coefficients. In this respect, the four explanatory models show the consistent result: namely, have the same sign of the *lnngd* coefficient. On the other hand, looking at the change of the individual coefficients by model, it can be said that the Model 2 and 5 are relatively stable since the values of individual coefficients change small in size. As well, the constant in the Model 2 and 5 is smaller than the one in the control model, whilst the one in the Model 3 and 4 is larger. It suggests that the change in the value of the dependent variable is explained better by the change in the value of the independent variables in the Model 2 and 5 than ones in Model 3 and 4.

Fourthly, looking at a p-value of the coefficients, the results imply that port-related variables in the Model 2 and 5 are strongly significant to the change of GVA per worker. In line with the result of the control model, the ratio of income invested in human capital (*lnSh*) and the regional GVA per worker in the previous year (*L.lny*) have the statistically significant relationship with the regional GVA per worker (*lny*); specifically, at the confidence level of 99%. On the one hand, in the case of the Model 2 and 5, the coefficients of three independent variables are statistically significant; port cargo traffics by RT (*lnRT*), the ratio of income invested in the human capital (*lnSh*) and the GVA per worker in previous year (*L.lny*) at the confidence level of 99%. On the other hand, in the Model 3 and 4, the coefficients of two independent variables are significant: specifically, *lnSh* and *L.lny* at the confidence level of 99% but *lnTEUp* and *lnTEUr* are not.

From the above discussions, it can be concluded that the port has the statistically significant contribution to the growth of regional economies: specifically, at the level of 0.0179 in elasticity according to the Model 2. Namely, the 1% increase in the growth rate of port traffics by RT may derive the 0.0179% increase in the growth rate of the GVA per worker.

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[115] It is inferred to be since several regions but not all have a national trade port and some of them have the container dedicated facilities.

6.5.3 Sub-group analyses

6.5.3.1 Sub-period analyses

The results of the sub-periods analyses are shown in Table 6-9, Table 6-10 and Table 6-11. Firstly, at the macro level, it can be said that the Korean economy has been changed quite rapidly and widely over decades. This can be derived from the fact that the coefficients of most control variables such as *lnngd, lnSk, lnSh*, and *lnrd,* change inconsistently in size and even in sign between sub-periods. Especially, the coefficients of *lnngd* and *lnSk* are inconsistent in the sign and the amount over time. This can be read to be consistent with the historical fact that the Korean economy has experienced such a huge up and down due to domestic and international economic events (Lee and Lam, 2017). Examples include the application of the relief finance to the International Monetary Fund (IMF) in 1998, the economic crisis triggered by the bankruptcy of a number of domestic financial corporations in 2001, and the shrunk trade volume due to the financial crisis in the USA in 2008 etc. In the statistical sight, the R-squared is slightly lower in the sub-period analysis than the one in the overall analysis. This can be interpreted that the values of panels appear to have quite bigger difference in the cross-sectional aspect rather than in the longitudinal aspect. As well, the statistics are likely to reflect the structural features of regional economies as considering that the Korean economy has such a concentrated port system (Song and Lee, 2017).

Secondly, focused on the goodness of fit in three sub-periods, it is clear that the explanatory models generally have the superior power compared to the control model. In the case of Model 2 and 5, the R-square in three sub-periods are greater than the one of the control model. However, in the case of Model 3 and 4, the R-square is bigger in the third sub-period than the one of the control model.

Lastly, at the level of the coefficient, the goodness of fit is slightly different over time. In the first sub-period, the control model has the four variables to meet the critical values: a variable (*lnSk*) at the confidence level of 90%, a variable (*lnSh*) at the confidence level of 95% and two variables (*lnngd* and *L.lny*) at the confidence level of 99%. The Model 2 has the four variables to meet the critical values: a variable (lnRT) at the confidence level of 90% and three variables (*lnngd, lnSh* and *L.lny*) at the confidence level of 99%. In the case of Model 3 and 4, there are two variables significant: a variable (*L.lny*) at the confidence level of 90% and a variable (*lnngd*) at the confidence level of 95%. The Model 5 has the four variables to meet the critical values: two variables (*lnSh* and *lnRT*) at the confidence level of 90% and two variables (*lnngd* and *L.lny*) at the confidence level of 95%. Looking at the second sub-period, the control model has three variables to meet the critical values but the explanatory models have two variables to do so. In the case of the third sub-period, the control model has four variables but Model 2, 3 and 5 have five variables statistically significant and Model 4 has four variables. Focused on the explanatory variable, the variable of *lnRT* meet the critical value in

Table 6-9 Regression results for the first sub-period (1994-2000)

Period	Model	1 (C Vars)		2 (RT)		3 (TEUp)		4 (TEUr)		5 (RT, ConP)	
		Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
1994-2000	lnngd	-0.0169	0.0030	-0.0256	0.0330	-0.0154	0.0200	-0.0154	0.0200	-0.0274	0.0340
	lnSk	0.0767	0.0710	0.0335	0.1990	0.0595	0.2360	0.0595	0.2360	0.0366	0.1880
	lnSh	0.1272	0.0240	0.1051	0.0330	0.0883	0.4930	0.0883	0.4930	0.0951	0.0660
	L1.lny	0.5645	0.0020	0.4174	0.0300	0.3290	0.0860	0.3290	0.0860	0.4048	0.0390
	lnrd	0.1072	0.3500	0.0472	0.6860	0.1426	0.3680	0.1426	0.3680	0.0494	0.6780
	lnRT			0.1090	0.0550					0.1146	0.0550
	lnTEUp					0.0006	0.9600				
	lnTEUr							0.0006	0.9600		
	ConP									0.0280	0.3830
	cons.	3.6397	0.0010	3.6477	0.0000	6.1193	0.0020	6.1193	0.0020	3.6813	0.0000
	Obs.	87		59		31		31		59	
R-square	within	0.7358		0.7427		0.4662		0.4662		0.7453	

Table 6-10 Regression results for the second sub-period (2001-2008)

Period	Model	1 (C Vars)		2 (RT)		3 (TEUp)		4 (TEUr)		5 (RT, ConP)	
		Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
2001-2008	lnngd	-0.0053	0.1450	-0.0050	0.2030	-0.0038	0.3560	-0.0038	0.3560	-0.0054	0.1960
	lnSk	-0.0285	0.2360	-0.0209	0.3760	-0.0333	0.2660	-0.0333	0.2660	-0.0217	0.3620
	lnSh	0.0849	0.0000	0.0542	0.0230	0.0579	0.0150	0.0579	0.0150	0.0549	0.0250
	L1.lny	0.8216	0.0000	0.8643	0.0000	0.8405	0.0000	0.8405	0.0000	0.8695	0.0000
	lnrd	0.0493	0.0710	0.0414	0.3920	0.0712	0.4030	0.0712	0.4030	0.0347	0.5030
	lnRT			0.0209	0.2440					0.0216	0.2250
	lnTEUp					-0.0003	0.9570				
	lnTEUr							-0.0003	0.9570		
	ConP									-0.0096	0.3260
	cons.	1.5696	0.0000	0.8600	0.0030	1.3946	0.0150	1.3946	0.0150	0.8202	0.0070
	Obs.	118		78		68		68		78	
R-square	within	0.9441		0.9534		0.9375		0.9375		0.9537	

Table 6-11 Regression results for the third sub-period (2009-2015)

Period	Model	1 (C Vars)		2 (RT)		3 (TEUp)		4 (TEUr)		5 (RT, ConP)	
		Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
2009-2015	lnngd	0.0159	0.1860	0.0351	0.0100	0.0365	0.0040	0.0389	0.0050	0.0342	0.0070
	lnSk	0.0723	0.0420	0.0513	0.0590	0.0673	0.0570	0.0650	0.0450	0.0523	0.0610
	lnSh	0.0394	0.0130	0.0544	0.0640	0.0577	0.0180	0.0559	0.0200	0.0562	0.0570
	L1.lny	0.6249	0.0000	0.4446	0.0000	0.5137	0.0000	0.5281	0.0000	0.4346	0.0000
	lnrd	0.0090	0.0880	0.0046	0.6600	0.0074	0.3080	0.0044	0.5350	0.0066	0.4790
	lnRT			0.0512	0.0720					0.0514	0.0730
	lnTEUp					0.0074	0.0160				
	lnTEUr							0.0043	0.1340		
	ConP									0.0060	0.3970
	cons.	3.6833	0.0020	4.7526	0.0000	4.7738	0.0000	4.6752	0.0000	4.8388	0.0000
	Obs.	111		76		76		76		76	
R-square	within	0.7005		0.7415		0.7325		0.7271		0.7429	

the first sub-period and the third one and the variable of *lnTEUp* are statistically significant just in the third sub-period. These estimators suggest that the relationship between the port traffic and the growth of regional economies are getting weaker over time: 0.109 in the first sub-period and 0.0512 in the third sub-period. As well, the results suggest that transportation at the national level and at the regional level has experienced the large-scale changes in the second sub-period.

In conclusion, the results of the sub-period analysis are generally consistent with the intuition that the statistics would be improved by applying three sub-periods if port-related activities had changed rapidly over time. This is based on the changes in the coefficients of explanatory variables. On the other hand, in the sight of R-square, the results seem to show that the power of the econometric analysis decreases significantly: in fact, even worse than what the author expected, even though considering the decrease of the observations and the degrees of freedom. In the different point of view, the results suggest that there is still such a huge difference in the values of panels by a region. Furthermore, the difference may influence estimating the parameters of the regression model and it may be bigger than the time-variant changes in the overall analysis.

6.5.3.2 Sub-region analyses

The results of the sub-region analyses are shown in Table 6-12 and Table 6-13. Firstly, in the sight of goodness of fit, the sub-region analysis show slightly different power by model. The values of R-square in the sub-region analysis with *lnRT* applied (Model 2-1, 2-2, 5-1 and 5-2) are slightly lower than the one in the basic models (Model 2 and 5). However, the values of R-square in the models with *lnRT* applied are slightly different: R-square in the model with large ports (Model 2-2 and 5-2) are slightly greater but the one without large ports (Model 3-1 and 4-1) are slightly lower than the one in the basic models.

Secondly, in terms of the coefficients, it can be said that the sub-region analyses show the different features between the regions with large ports and the ones without large ports. Even though the estimators of two control variables (*lnSh* and *L.lny*) are generally significant at the confidence level of 95%, the coefficients suggest different implications. The variable of *lnSh* contributes to the growth of regional economies more strongly in the regions with large ports than in the regions without large ports. On the contrary, the variable of *L.lny* contributes to the growth of regional economic much more in the regions without large ports than in the one without large ports. In addition, it is considerable that the coefficient of the variable of *lnSk* shows quite different feature in size and even in sign; the estimator has negative sign in the regions with large ports, even though the estimators do not meet the critical values.

Table 6-12 Regression results of the sub-regional analysis (Model 2 and 5)

Period	Model	2 (RT)		2-1 ($RT^{<}$)		2-2 ($RT^{>}$)		5 (RT, ConP)		5-1 ($RT^{<}$, ConP)		5-2 ($RT^{>}$, ConP)	
		Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
1990-2015	lnngd	-0.0029	0.5750	-0.0028	0.7000	-0.0024	0.6680	-0.0030	0.5730	-0.0030	0.6790	-0.0024	0.6760
	lnSk	0.0290	0.2630	0.0406	0.1890	-0.0058	0.8570	0.0308	0.2610	0.0431	0.1620	-0.0098	0.7480
	lnSh	0.0565	0.0060	0.0619	0.0050	0.1182	0.0000	0.0557	0.0080	0.0606	0.0050	0.1195	0.0000
	L1.lny	0.8176	0.0000	0.8279	0.0000	0.5947	0.0000	0.8157	0.0000	0.8186	0.0000	0.5994	0.0000
	lnrd	0.0153	0.5490	0.0072	0.8280	0.0540	0.2630	0.0171	0.5030	0.0151	0.6430	0.0525	0.2690
	lnRT	0.0179	0.0050	0.0095	0.5760	0.0674	0.0040	0.0173	0.0050	0.0079	0.6220	0.0666	0.0060
	lnTEUp												
	lnTEUr												
	ConP							0.0042	0.4820	0.0119	0.1690	-0.0061	0.7540
	cons.	1.3532	0.0010	1.3722	0.0130	2.6108	0.0000	1.3728	0.0010	1.4619	0.0060	2.1484	0.0000
	Obs.	213		128		85		213		128		85	
R-square	within	0.9769		0.9723		0.9745		0.9769		0.9725		0.9745	

Note: $RT^{<}$; indicating that RT is not more than 80 million RT.
$RT^{>}$; indicating that RT is more than 80 million RT.

Table 6-13 Regression results of the sub-regional analysis (Model 3 and 4)

Period	Model	3 (TEUp)		3-1 ($TEUp^{<}$)		3-2 ($TEUp^{>}$)		4 (TEUr)		4-1 ($TEUr^{<}$)		4-2 ($TEUr^{>}$)	
		Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
1990-2015	lnngd	-0.0019	0.6900	0.0053	0.3960	0.0004	0.9630	-0.0020	0.6650	0.0071	0.3820	-0.0004	0.9550
	lnSk	0.0425	0.1440	0.0652	0.1010	-0.0053	0.8740	0.0463	0.1640	0.0853	0.1440	-0.0039	0.8990
	lnSh	0.0843	0.0020	0.0757	0.0080	0.1100	0.0170	0.0862	0.0010	0.0940	0.0010	0.0968	0.0420
	L1.lny	0.7489	0.0000	0.7632	0.0000	0.5706	0.0010	0.7330	0.0000	0.6891	0.0000	0.6628	0.0000
	lnrd	0.0418	0.0970	0.0296	0.1890	0.0696	0.2630	0.0441	0.1020	0.0381	0.0990	0.0561	0.3530
	lnRT												
	lnTEUp	0.0008	0.6020	-0.0005	0.7320	0.0392	0.0300						
	lnTEUr							0.0020	0.4900	0.0013	0.7040	0.0212	0.0730
	ConP												
	cons.	2.1791	0.0000	2.0272	0.0000	3.5466	0.0030	2.3090	0.0000	2.6515	0.0060	2.8847	0.0070
	Obs.	175		85		90		175		78		97	
R-square	within	0.9651		0.9512		0.9670		0.9653		0.9412		0.9618	

Note: $TEUp^{<}$; indicating that TEUp is not more than 100 thousand TEUs.
$TEUp^{>}$; indicating that TEUp is more than 100 thousand TEUs.
$TEUr^{<}$; indicating that TEUp is not more than 100 thousand TEUs.
$TEUr^{>}$; indicating that TEUp is more than 100 thousand TEUs.

Focused on the explanatory variables, the results clearly suggest that whether the ports contribute to the growth of regional economies or not depends mainly on the magnitude of each port; especially, port traffic. In the case of the regions without large ports with *lnRT* applied (Models 2-1 and 5-1), the coefficients are slightly lower than the single coefficient estimated with the whole regions

(Models 2 and 5).[116] On the other hand, in the case of the regions with large ports (Models 2-2 and 5-2), the coefficients is almost 4 times as great as the one in the overall analysis. In the case of the variables measured by *TEUp* and *TEUr* (Model 3 and 4), the difference between the regions with large ports and the ones without large ports is significantly bigger than one in the models with *lnRT* applied (Model 2 and 5). Especially, in the case of Models 3-2 and 4-2, the coefficient of the explanatory variables is significantly higher than the one in Models 3 and 4.[117] From the coefficient and the p-values of the explanatory variables, it can be inferred that the port-related activities can contribute much more to the growth of regional economies as the volume of port traffic increases. It can be said that the regions with large ports may have experienced some economic effects such as the economy of scale, the economy of scope and the agglomeration effects centred on the port area.[118]

In conclusion, the results of the sub-region analysis suggest several significant implications. Firstly, the statistics can suggest that the biased relationship between the independent variables and the dependent variable can be estimated in that the difference between panels by region is regarded as an outlier. It can happen mainly on the assumption that panels are homogeneous even in case that the heterogeneity is recognized (Blackburne and Frank, 2007).[119] For example, the coefficients of the explanatory variables in the basic models (Model 2, 3, 4 and 5) are the representative as the mean of both the ones in the models (Model 2-1, 3-1, 4-1 and 5-1) without large ports and the ones in the models (Model 2-2, 3-2, 4-2, and 5-2) with large ports. This result is quite reasonable, as considering the two-way scatters in Figure 6-1, since the sub-region analyses mean estimating different coefficients and constant for the sub-groups with different characteristics.

As a result, if a single coefficient estimated with the whole panel is interpreted on the assumption of homogeneity or weak heterogeneity,[120] the statistics may be distorted; overestimated in the case of the regions without large ports but underestimated in the case of the regions with large ports. This suggests that economic impact analyses put a lot of caution to understand the results from the top-down method such as the IO analysis.[121]

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[116] The coefficient of the explanatory variables are not significant at the confidence level of 95% in the Model 2-1 and 5-1, but the one in the Model 2 and 5 and in the Model 2-2 and 5-2 are at the confidence level of 99%.
[117] In the aspect of p-value, the coefficients of the explanatory variables in the Model 3-1 and 4-1 as well as the Model 3 and 4 are not significant at the confidence level of 95%, but the one in the Model 3-2 and 4-2 are significant at the confidence level of 95% and 90% respectively.
[118] In the case of estimating a single coefficient, the values in the regions with large ports can be treated as an outlier rather than as economic effects.
[119] Specifically, in the case of port studies, it may be obtained by depending on the statistical analysis without a contextual understanding of each port such as the historical trajectory of a port, the composition of cargo types, and the service boundary of a port.
[120] The regression is conducted to estimate the coefficients of variables based on the assumption that the parameters have one value; the relationship between the independent variables and the dependent variable are statistically consistent by a region
[121] The IO table is usually calculated at the level of the national economy and the relationship between industries is applied to the IO table at the level of a regional economy.

6.5.4 Summary

By implementing the statistical analyses, this study obtains some significant results as follows. Firstly, from the results of the overall analysis, this study suggests that the ports contribute to the growth of the regional economies. The growth rate of a regional economy increases by 0.018% when the port traffic measured by RT increases by 1%. However, the port traffic by TEU does not seem to have a significant relationship with the regional economic growth. Secondly, from the results of the sub-period analysis, it can be said that the statistical relationship between the growth rate of the port traffic and the growth rate of regional economies was quite strong in the 1990s but became very unstable after the 2000s. In addition, it is clear that the economic impacts of the port traffic on the regional economies have been smaller over time. This can be inferred from the fact that the coefficient of port traffic by RT in the third sub-period analysis lessens compared to the one in the first sub-period analysis.[122] Lastly, from the results of the sub-region analysis, this study suggests that the growth rate of the port traffic in the regions with large ports contributes much more to the growth rate of the regional economies than in the regions without large ports. This can be known from the statistics of the coefficient and the p-values. As well, the economic impacts of a port on the regional economy is much more sensitive to the amount of the port traffic by TEU than the one by RT.

[122] Although the coefficient of the explanatory variable in the third sub-period analysis doesn't meet the confidence level of 90%, the p-value is 0.1140 so that there is no reason to evaluate that the statistics don't have any meaning.

6.6 Post-estimation Test

6.6.1 Introduction

This study introduced the results of parameter estimation and sub-group analyses in the previous section considering the post-estimation tests such as the test for the variables and the residuals. However, it is inappropriate to interpret that the results in the previous section are confirmed, although the parameter estimation is conducted taking into account consideration of the disturbance of the variables and the residuals. This is because the estimators and the p-values of the coefficients are based on the statistical-interactive relationship between the independent variables and the dependent variable (Granger, 1969). As a result, the statistics in the previous section cannot confirm the direction of the influence between the variables.

In order to clarify the direction of the influence between the variables, the empirical research is necessary to test the causality (Lopez and Weber, 2017). This study introduces the causality test focused on the Granger causality test.

6.6.2 Test of causality

6.6.2.1 Introduction

According to Pindyck and Rubinfeld (1988), the causality test suggested by Granger (1969) consists of two steps; one is to test whether *X* causes *Y* and the other is to test whether *Y* does not cause *X*. In addition, each step has two different regressions: so-called, the ‘unrestricted’ regression and a ‘restricted’ regression, and the F-test between the two regression.

Unrestricted regression: $Y = \alpha + \sum_{i=1}^{m} \beta_i Y_{t-i} + \sum_{i=1}^{m} \gamma_i X_{t-i} + \epsilon_t$ 7-2)

Restricted regression: $Y = \alpha + \sum_{i=1}^{m} \beta_i Y_{t-i} + \epsilon_t$ 7-3)

As the first step, the former is to test the null hypothesis that ‘X does not cause Y’ by regressing Y against lagged values of Y and lagged values of X. The latter is to test the null hypothesis by regressing Y just against lagged values of Y. The F-statistic calculated with the sum of squared residuals from two regressions implies whether the group of coefficients are significantly different from zero. As the second step, the above procedure is repeated to test the null hypothesis that ‘Y does not cause X’ with the regression functions which the variables of X and Y are switched. To confirm that X is a significant independent variable with regard to the change of Y, the hypothesis that ‘X does not cause Y’ must be rejected but the hypothesis that ‘Y does not cause X’ should not.

Freeman (1983) suggested the 'direct Granger method' that is the methodology to determine the causality direction between two variables and to examine the null hypothesis that the coefficients are equal to zero.[123] In this point, the direct Granger method is much more efficient than the original Granger model. According to Shan et al. (2014), the regression model with two unit lagged variables applied to the Granger causality test is arranged as below;

$$X = a_1 L.X + a_2 L2.X + b_1 L.Y + b_2 L2.Y + \epsilon_{i,t} \qquad 7\text{-}4)$$

where X is an independent variable and Y is the dependent variable in the regression model, L means one lagged value (t-1) and $L2$ means two years lagged value (t-2), and $\epsilon_{i,t}$ is the error term.

Meanwhile, Dumitrescu and Hurlin (2012)[124] provide an extended methodology to detect the causality in panel data in the line of previous approaches as below;

$$Y_{i,t-k} = \alpha + \sum_{k=1}^{K} \beta_{ik} Y_{i,t-k} + \sum_{k=1}^{K} \gamma_{ik} X_{i,t-k} + \epsilon_{i,t}. \qquad 7\text{-}5)$$

where $X_{i,t-k}$ and $Y_{i,t-k}$ are the observations of two stationary variables for individual i in period t.

6.3.2.2 Empirical application

This study tried to conduct the Granger causality test based on the former two methods due to the feature of the model by Dumitrescu and Hurlin (2012).[125] This study applies the two-step test method by Granger (1969) considering the feature that clarifies the direction of influence between two variables. Meanwhile, the method by Freeman (1983) is applied in the point that it can supply the statistics of the coefficients and the F-test at the same time.

The 1st step: $lnX = a_1 L.lnX + a_2 L2.lnX + b_1 L.lnY + b_2 L2.lnY + \epsilon_{i,t}$ 7-6)

The 2nd step: $lnY = a_1 L.lnY + a_2 L2.lnY + b_1 L.lnX + b_2 L2.lnX + \epsilon_{i,t}$ 7-7)

As Pindyck and Rubinfeld (1988) mentioned, the extent to which lags are applied to each variable is not clearly defined so that it is quite arbitrary in empirical analysis. With regard to this, this study applies two lagged variables considering the highest goodness of fit that is in two lagged model in the sight of adjusted R-squared as shown in appendix A.6.2.2 and the consistency with the application in previous studies (Shan et al., 2014).

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[123] The method consists of two steps: regress one variable on the lagged values of the other variable and itself; then use the F-test to examine the null hypothesis that all the coefficients on the lagged values of the other variable are zero. So the other variable is said not to have 'Granger causality' if the null hypothesis is not rejected.

[124] This model is the default approach in Stata for the Granger causality test in panel data.

[125] The model with the command of '*xtgcause*' in Stata requests that the panel data is strongly balanced so the command was not conducted normally with the data in this study.

Table 6-14 Results of the Granger causality test between lny and lnRT

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT
lny	Coef.	0.8089	0.1230	-0.0521	0.0523	8.96	16.84	0.0070	0.0010
	S.E.	0.0701	0.0801	0.0174	0.0128				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnRT	L2.lnRT	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnRT	Coef.	0.9139	-0.0626	0.3012	-0.1808	2.03	0.74	0.1710	0.4010
	S.E.	0.0821	0.0825	0.2115	0.2105				

Note: L. indicates the figure one year before and L2. does the one in two years before.
Coef. and S.E. mean coefficients and standard error respectively.

Table 6-15 Results of the Granger causality test between lny and lnTEUp

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnTEUp	L2.lnTEUp	L.lnTEUp	L2.lnTEUp	L.lnTEUp	L2.lnTEUp
lny	Coef.	0.8364	0.0983	0.0009	-0.0021	0.05	0.25	0.8340	0.6250
	S.E.	0.0843	0.0889	0.0043	0.0043				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnTEUp	L2.lnTEUp	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnTEUp	Coef.	1.0544	-0.2110	-0.1729	0.2247	0.05	0.09	0.8200	0.7640
	S.E.	0.0505	0.0394	0.7495	0.7413				

Table 6-16 Results of the Granger causality test between lny and lnTEUr

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnTEUr	L2.lnTEUr	L.lnTEUr	L2.lnTEUr	L.lnTEUr	L2.lnTEUr
lny	Coef.	0.8284	0.1218	0.0004	-0.0037	0.01	0.80	0.9150	0.3810
	S.E.	0.0780	0.0813	0.0036	0.0041				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnTEUr	L2.lnTEUr	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnTEUr	Coef.	1.0423	-0.2103	0.1509	0.4332	0.06	0.42	0.8150	0.5210
	S.E.	0.0662	0.0385	0.6371	0.6652				

6.3.2.3 The results

The results of the Granger causality test between the dependent variable and an explanatory variable are shown in Table 6-14, Table 6-15 and Table 6-16. On one hand, the test results in Table 6-14 show that the null hypothesis, which '*lnRT* does not cause *lny*', is strongly rejected at the confidence level of 99% since the p-values of the F-test are quite low; however, the null hypothesis, which '*lny* does not cause *lnRT*', is not rejected. It means that an explanatory variable of *lnRT* has the Granger causality and the results in the previous section are statistically significant.

On the other hand, the results in Table 6-15 and Table 6-16 are quite different from the ones in Table 6-14. Both null hypotheses that '*lnTEUp* does not cause *lny*' and that '*lny* does not cause *lnTEUp*' are not rejected at the confidence level of 95% due to the p-values of the F-test which are greater than 0.7. The results in the case of *lnTEUr* are quite similar; both null hypotheses are not rejected and the explanatory variable of *lnTEUr* doesn't have the Granger causality.

What the results above imply basically depends on the definition of the Granger causality. Granger (1969) makes it clear that the definition of causality is entirely related to the predictability of a time-series.[126] So the results of the Granger causality test do not disaffirm the results of parameter estimation and the statistical relationship between the independent variables and the dependent variable. For this reason, it is necessary that empirical research carefully interpret the results of the Granger causality test for panel data.

6.6.3 Summary

In this section, this study introduces the results of the post-estimation tests focused on the causality test since the other tests; for example, the test for goodness of fit, test for variables, and test for the residuals, are discussed in the previous section. As a result, the explanatory variable measured by RT has the Granger causality but the other explanatory variables measured by TEU do not cause the dependent variable of the logarithmic GVA per worker; as well the dependent variable does not cause the explanatory variable. These results imply that this study needs to carefully interpret the results of parameter estimations in the previous section but not deny the whole results. Considering the above result, this study discusses the significant implications of the results in the next section.

[126] Granger clearly suggests the definition of causality (see Granger (1969, p.430) for the detailed). As well, it can be said that *X* causes *Y* in the case that 'some other series Y_t contains information in past terms that helps in the prediction of X_t but this information is contained no other series used in the predictor.'

6.7 Findings

This study introduces the process of the econometric analysis and the results of each analysis. Based on the results, this study suggests some key findings and implications as following.

6.7.1 Overall analysis

This study conducts the econometric analysis with the four models which apply the control variables and the port-related variable as an explanatory variable. As a result, it is suggested that the model with *lnRT* applied, in the sight of the goodness of fit, is superior to the models of applying the variables of *lnTEUp* and *lnTEUr*. This result seems not to be in line with the result in the previous chapter that the GVA per worker of transportation is higher in the port regions with the large container traffic than the regions without seaports or with a small amount of the container traffic. However, the above two results are not contradictory for each other since the two are based on the different perspectives. The container freights contribute to the GVA per worker of transportation much more since they are necessary for more related or additional activities. On the other hand, the port traffic measured by RT has a stronger statistical relationship with the GVA per worker than the port traffic measured by TEU since the former has comparatively smaller gaps between regions and more stable statistically. In conclusion, it is not appropriate to interpret that bulk cargo contributes much more to the growth of a regional economy, even though the port traffic measured by RT has the statistically stronger relationship with the variables in the regional economy.

6.7.2 Sub-groups analysis

The sub-group analyses in which this study has the originality supply some implications as below. Firstly, it can be said that the economic contribution of the major ports on the regional economy has decreased gradually decade by decade as considering the parameters of the explanatory variable in the first sub-period and the third period. Meanwhile, the number of observations and the degree of freedom decrease due to the split of the data so that the power of the sub-group analysis is not as good as the intuition of the author[127] in the sight of the goodness of fit.

Secondly, the results of the sub-region analysis supply some interesting implications in the sight of the scale of port traffic. Above all, it can be understood that the regions with large ports have the higher coefficients regardless of the explanatory variable. Secondly, the coefficient estimators of the explanatory variable in the regions with large ports are significantly larger than the ones in the whole

[127] Initially, the author expected that the application of the sub-period would enhance the power of the model in the sight of the goodness of fit if the extent what the port traffic contributed to the regional economy has changed drastically over time. However, the actual results are different from the prediction since the decrease in the number of observations and degrees of freedom may influence much more the goodness of fit than the longitudinal change.

analysis. Meanwhile, in the case of the regions without large ports, the coefficient estimators are smaller than the ones in the whole analysis. This is in line with the intuition that the ports with large port traffic may contribute to the regional economy much more than the ones with small port traffic and with the work by Danielis and Gregori (2013). This is natural in the sight of the statistics. However, the power of the model in the case of the regions without large ports is not as good as the estimators are effective statistically due to the great figure of p-values. Lastly, the results of the comparative analysis between the regions with large ports and the ones without large ports provide important implications to the econometric analysis for the panel data. Namely, the results show that the econometric analysis of estimating a single coefficient can supply the biased results of the underestimation or the overestimation with regard to the relationship between port variables and the regional economic growth if not considering the characteristics of the regional economies and the port traffics. Specifically, the effect of large ports may be underestimated but the effect of small ports may be overestimated when the former and the latter are analysed together.

Finally, this study can conclude that the ports in South Korea have a larger disparity in the extent that a port contributes to the regional economy in the sight of the scale of an individual port rather than the changes in the economic relationship over time. It is supported by the differences in the goodness of fit, the coefficient estimators and the p-values In the sight of the goodness of fit, the sub-period analysis has worse R-squared than the whole analysis, but the sub-region analysis has similar R-squared as the whole analysis. As well, the estimators in the sub-group analysis show more consistent rather than the ones in the sub-period analysis, and the p-values of the coefficients in the sub-region analysis are more stable than the one in the sub-period analysis.

6.7.3 Comprehensive evaluation

The results of the various analyses in this chapter can be interpreted to support that the economic impact of the port on the region is statistically valid. However, assumed that the 16 regions have a single coefficient, the parameter estimators of the variables with the panel data applied is likely to be over-estimated or under-estimated. As a result, it should be considered what the results of the analysis to estimate the specific parameter for individual regions are while comparing with the ones in this chapter.

Chapter 7 Application of Econometric Analysis by Region

7.1 Overview

This study introduces the results of empirical analyses by applying different methodologies in the three previous chapters. As discussed in section 5 in chapter 4, each methodology has its own feature and contributes to both conducting the following empirical analysis and understanding the results from the analysis. Namely, the key findings from chapter 4 supply the concrete background for understanding the features of the structural changes of transportation in the four port regions. As well, the ones from chapter 5 play a critical role as the criteria in conducting the econometric analyses and interpreting the results. In detail, this study selects the FE model of regressing for the panel data and suggests the risk of underestimation or overestimation when a single coefficient is estimated for the whole regions, as considering the quite different pattern in the annual changes in the GVA per worker of the four sub-sectors in transportation in chapter 5. Nevertheless, this study cannot be free from the criticism that the methodological connection is quite loose and subjective.

For this reason, this study tries to make a direct relationship between the shift-share analysis and the econometric analysis in this chapter. To do so, this study is necessary for reviewing the features of the two methodologies. As shown in Table 7-1, the shift-share analysis in chapter 5 is focusing on examining some patterns in the annual changes in the GVA per worker of transportation and of the four sub-sectors in transportation in the four port regions. On the other hand, the econometric analysis in chapter 6 is focusing on estimating the statistical relationship between the port-related variables and the growth of regional economies by using the regression model for the panel data. As a result, the shift-share analysis and the econometric analysis are used for looking at different information with the data from the different sectoral scope. The former is focused on the changes in transportation and the latter is conducted at the level of the regional economy. As such, this study has two practical options to connect the two methodologies; one is putting the results from the former in the latter and the other is applying the latter at the disaggregated level of the former. Namely, the first way means

Table 7-1 Comparison of methodological features between chapter 5 and chapter 6

Chap.	Methodology	Key information	Variables	Research scopes
5	Shift-share	Trend in disaggregated changes (GE, IM CE)	GVA per worker of transportation (*yt*) and of four sub-sectors in transportation	Four port regions, 1990-2015, 2000-2015
6	Econometric	Statistical relationship	Regional GVA per worker (*y*), production factors (*ngd, Sk* and *Sh*), transport-related ones (*rd, RT, TEUp,* and *TEUr*)	16 regions, 1990-2015

that the econometric analysis is conducted as applying some annual values from the former such as industry mic (IM) and competitive effect (CE) as an additional variable. Meanwhile, the second states that the econometric analysis is conducted at the level of transportation by applying the data disaggregated at the level of a sector in a regional economy from the level of the whole regional economy. This implies that this study needs to gather further data and think about how to keep the consistent relationship between the empirical analyses. As such, this study selects the first way to make a direct connection between the shift-share analysis and the econometric analysis.

The empirical analysis in this chapter is fundamentally in the line of the econometric analysis in the previous chapter. In the sight of the research objective, this chapter focuses on keeping the consistency with the results of the econometric analysis. To do so, this chapter conducts the analysis with the Model 2, in which port traffic measured by RT (*lnRT*) is applied as an explanatory variable and has the best goodness of fit among the models for the entire studied period. As well, applying the econometric analysis by region is consistently on the insight that this study introduced the sub-group analysis in order to examine if estimating a single coefficient for the whole regions may supply the somewhat biased information. The risk of underestimation or overestimation may get greater as considering the results[128] of the shift-share analysis. Lastly, this study applies an additional variable of IM and CE generated by the shift-share analysis in order to examine if the annual changes beyond the average growth of the national economy and the national transportation may contribute to the growth of regional economies.

On the other hand, in the sight of the research procedure, this chapter follows the whole procedure of the econometric analysis in the previous chapter. However, the overlapped procedure and the shared contents with the ones in the previous chapter are basically left out. For example, the tests for data stationarity in the previous chapter are omitted in this chapter. In addition, theoretical reviews on various tests are not handled and just the results of the empirical analysis are focused on. Lastly, this study conducts the econometric analysis for the regions which the four major ports are located in as considering the constraints of space and the research objectives.

In the following section, this study introduces the results of the correlation analysis between key variables at the level of a regional economy and compares those with the ones from the panel data in the previous chapter. In the third section, this study discusses the results of the econometric analysis at the level of a region. As well, the results of the regression analysis are compared for the ones in the previous chapter. Lastly, the findings and the implications from the regional regression analysis are discussed in the fourth section.

[128] The GVA per worker in the regional transportation implies that four major port regions have quite different features in amount and in annual changes; especially, Incheon and Busan have recorded higher GVA per worker in transportation even compared to Ulsan and Jeonnam.

7.2 Descriptive Analysis

The results of the correlation analysis between nine independent variables and the GVA per worker in 16 regions are shown in Table 7-2. As well, the table shows the results of the correlation analysis with the entire panel data introduced in the previous chapter. The observation clearly shows the features of the two correlation analyses. The former has the observations of 21 in most regions except for Ulsan whose observation is 17 and the latter has the observations of 322. As a result, the critical value of the analysis is changed; around 0.11 in the latter but 0.4329 in the case of 15 regions except for Ulsan whose critical value is 0.4821.

From the table, some significant features can be summarised. Firstly, the GVA per worker in the previous time is highly correlated with the GVA per worker as a whole: namely, the result is not affected by the analytical method. In this line, the ratio of income invested in human capital (*Sh*) shows quite a high correlation coefficient as a whole. However, the other variables: for instance, the GVA per worker in transportation (*yt*), capital depreciation (*ngd*), the ratio of income invested in physical capital (*Sk*) and road density (*rd*), show that the correlation coefficients are quite different by the analytic method and between regions in the econometric analysis by region. Lastly, the correlation coefficients of port traffic in a regional analysis show quite larger than the ones in the whole analysis for the panel data. As well, the coefficients of port traffic by RT is relatively stable compared to the ones by TEU.

Table 7-2 Results of correlation analysis with the panel data and within a region

		obs	y	L.y	yt	ngd	Sk	Sh	rd	RT	TEUp	TEUr
Whole panel		322	1	0.9960	0.2293	-0.0634	0.6861	0.2598	-0.0114	0.5782	-0.0757	-0.0151
1	Seoul	21	1	0.9963	-0.1419	0.4314	0.5441	0.9691	0.3264	-	-	-
2	Busan	21	1	0.9879	0.7886	-0.0443	0.7369	0.9624	0.9513	0.9619	0.9685	0.9514
3	Daegu	21	1	0.9825	0.2724	-0.4519	0.7692	0.9769	0.9465	-	-	-
4	Incheon	21	1	0.9650	0.9830	-0.3578	0.6746	0.9684	0.6302	0.8844	0.9461	0.9461
5	Gwangju	21	1	0.9857	-0.2583	-0.5741	0.6544	0.9579	0.8582	-	-	-
6	Daejeon	21	1	0.9701	0.8230	-0.7992	0.5455	0.9406	0.7919	-	-	-
7	Ulsan	17	1	0.9500	-0.4309	-0.4076	0.5944	0.9396	0.5228	0.9228	0.8522	0.8522
8	Gyeonggi	21	1	0.9929	0.9844	-0.8382	-0.4040	0.9836	-0.1050	0.9353	0.9705	0.9705
9	Gangwon	21	1	0.9828	0.8837	0.2826	0.7195	0.9556	0.9276	0.9350	0.5446	0.5446
10	Chungbuk	21	1	0.9888	0.9702	-0.0788	0.5489	0.9553	0.8882	-	-	-
11	Chungnam	21	1	0.9939	0.9465	-0.0522	0.3184	0.9668	0.7349	0.9255	0.8110	0.8110
12	Jeonbuk	21	1	0.9895	0.9312	0.0922	0.8438	0.9564	0.9452	0.9594	0.7613	0.7659
13	Jeonnam	21	1	0.9893	0.9588	0.4064	-0.0472	0.9902	0.9624	0.9708	0.9748	0.9748
14	Gyeongbuk	21	1	0.9934	0.9539	0.3541	-0.8102	0.9550	0.9819	0.9499	0.7106	0.7106
15	Gyeongnam	21	1	0.9699	0.7643	0.2000	0.3396	0.9098	0.8148	0.9282	-0.5702	0.7995
16	Jeju	21	1	0.9873	0.9203	0.4941	0.8109	0.9460	0.7824	0.0063	0.9213	0.9213

Note: the critical value is 0.4329 in 19 degrees of freedom and 0.4821 in 15 degrees of freedom.

7.3 Econometric Analysis

The econometric analysis in this chapter is conducted at the level of a regional economy, as considering the results of the shift-share analysis in Chapter 5. This is supposed to help to understand the results of the econometric analysis in Chapter 6. In addition, it is expected that this section provides some implications in the point of understanding the features of three different methodologies through estimating and comparing the coefficients of the independent variables.

7.3.1 Specification of analysis

The regression function is changed to the form for time-series data (*t*) by region instead of the panel data (*i* and *t*). This is repeated as follows:

$$\ln y_t = \beta_0 + \beta_1 \ln(n_t + g_t + \delta_t) + \beta_2 \ln s_{k,t} + \beta_3 \ln s_{h,t} + \beta_4 \ln y_{t-1} + \beta_5 \ln rd_t + \gamma \ln RT_t + u_t \qquad 8\text{-}1)$$

where, β_0; intercept, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_{5,}\ \gamma$; coefficients, RT_t; port cargo traffic measured by RT, u_t; the error term.

Based on this regression function, this study applies an additional variable transferred from the annual values of the IM and the CE of the shift-share analysis for the four port regions. The regression function can be rewritten as below:

$$\ln y_t = \beta_0 + \beta_i CV_t + \gamma_1 \ln RT_t + \gamma_2 AV_t + u_t \qquad 8\text{-}2)$$

where, β_0; intercept, β_i, γ_1, γ_2; coefficients, CV_t; control variables, RT_t; port traffic measured by RT, AV_t; additional variable from the shift-share analysis, u_t; the error term.

7.3.2 Preliminary estimation of parameters

7.3.2.1 Application by region

As mentioned above, estimating a single coefficient of individual independent variables is introduced in the previous chapter. On the contrary, this chapter is focusing on estimating the coefficients of the independent variables by region. In other words, this chapter introduces the results of regressing the variables with time-series data by each region. The results in Table 7-3 are obtained by repeatedly regressing for each time-series data in 16 regions. In the sight of the observation, five regions such as Seoul, Daegu, Gwangju, Daejeon and Chungbuk do not show any result since those are an inland city or region. In the sight of goodness of fit, 11 individual regressions have such a high R-square, as shown in Appendix 6 (A.6.2), but do not have the sufficient estimators that are statistically significant at the confidence level of 90%; in fact, each regional regression for the four major port regions generally has one or two significant variables that are underlined. It may imply that individual

Table 7-3 Results of the multiple regression at the level of a region

		lnngd	lnSk	lnSh	L.lny	lnrd	lnRT	Cons	Notes
Whole panel	Coef.	-0.0029	0.0290	0.0565	0.8176	0.0153	0.0179	1.3532	
	P-value	0.5750	0.2630	0.0060	0.0000	0.5490	0.0050	0.0010	
1 Seoul	Coef.	-	-	-	-	-	-	-	No port
	p-value								
2 Busan	Coef.	-0.0015	-0.0022	0.1094	0.4666	0.1489	0.0683	3.4895	Obs: 20
	P-value	0.8110	0.9740	0.1610	0.0250	0.2330	0.2660	0.0170	
3 Daegu	Coef.	-	-	-	-	-	-	-	No port
	P-value								
4 Incheon	Coef.	-0.0131	-0.0991	0.2776	0.2038	-0.1279	0.2998	2.6497	Obs: 21
	P-value	0.3990	0.3140	0.0110	0.3790	0.2400	0.0450	0.2070	
5 Gwangju	Coef.	-	-	-	-	-	-	-	No port
	P-value								
6 Daejeon	Coef.	-	-	-	-	-	-	-	No port
	P-value								
7 Ulsan	Coef.	-0.0321	-0.0875	0.0355	0.4254	-0.0947	0.4384	-1.2525	Obs: 17
	P-value	0.3850	0.2740	0.7020	0.0060	0.2160	0.0160	0.6970	
8 Gyeonggi	Coef.	0.0323	0.0541	0.2372	0.5787	0.0636	0.0352	2.6874	Obs: 21
	P-value	0.3720	0.4750	0.0230	0.0150	0.4680	0.4740	0.1060	
9 Gangwon	Coef.	0.0227	0.0703	0.1419	0.2831	0.1084	0.1777	3.4086	Obs: 21
	P-value	0.0160	0.2200	0.0140	0.0620	0.2300	0.1070	0.0140	
10 Chungbuk	Coef.	-	-	-	-	-	-	-	No port
	P-value								
11 Chungnam	Coef.	0.0182	0.0744	0.1245	0.6922	0.1011	0.0547	1.4508	Obs: 20
	P-value	0.3200	0.1690	0.2430	0.0010	0.1650	0.3280	0.1080	
12 Jeonbuk	Coef.	0.0056	0.0860	0.0987	0.4707	-0.0157	0.1962	1.8681	Obs: 18
	P-value	0.6160	0.1050	0.1820	0.0030	0.8620	0.0390	0.0360	
13 Jeonnam	Coef.	-0.0025	-0.0069	0.1029	0.5846	-0.0775	0.2698	-0.5829	Obs: 15
	P-value	0.8810	0.9480	0.5610	0.0980	0.7450	0.2220	0.8460	
14 Gyeongbuk	Coef.	0.0004	0.0078	-0.1235	0.6555	0.3560	0.3209	-3.1171	Obs: 19
	P-value	0.9700	0.9370	0.3060	0.0350	0.1680	0.1540	0.2760	
15 Gyeongnam	Coef.	0.0113	0.2884	0.0760	0.5943	0.0591	0.0809	1.6916	Obs: 20
	P-value	0.8510	0.0430	0.6150	0.0860	0.7820	0.6170	0.3450	
16 Jeju	Coef.	0.0322	0.0728	0.0406	0.7939	0.0102	-0.0878	3.1177	Obs: 21
	P-value	0.2080	0.2550	0.6580	0.0000	0.8160	0.0510	0.0070	

Note: obs indicates the number of observation

Underlined p-values are statistically significant at the confidence level of 90%.

regressions may have a multicollinearity so that it is careful to interpret the results of the regression. As such, interpreting the results of the regression is introduced after the post-estimation tests. However, it is a remarkable feature that the coefficients of *lnSh* and *lnRT* are considerably bigger than the one in the regression for the whole panel data. It implies that the ratio of income invested in the human capital and port traffic contribute to the growth of regional economies much greater than what estimated in the previous chapter.

7.3.2.2 Further analysis for four port regions

This study conducts the additional regressing, as shown in Table 7-4, by applying the variables of industrial mix (IM) and competitive effective (CE) generated from the shift-share analysis in Chapter 5. Why this study applies IM and CE is that the regional GVA per worker, as discussed in Chapter 5, is strongly correlated with the CE in Busan, Incheon, and Jeonnam and the IM in Ulsan. At a glance, applying additional variable is helpful to increase the adjusted R-square so that parameter estimation and post-estimation test would better be conducted with the three different models applied.

Table 7-4 Preliminary results of estimating of parameters

Model	Busan						Incheon					
	1-1		1-2 (CE)		1-3 (IM)		2-1		2-2 (CE)		2-3 (IM)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
lnngd	-0.00153	0.811	0.00169	0.776	-0.00985	0.171	-0.01313	0.399	0.00303	0.853	-0.02272	0.164
lnSk	-0.00224	0.974	0.02612	0.679	-0.04250	0.509	-0.09909	0.314	-0.12665	0.172	-0.04643	0.634
lnSh	0.10944	0.161	0.15848	0.042	0.15040	0.047	0.27765	0.011	0.28992	0.005	0.22488	0.034
L1.lny	0.46661	0.025	0.43400	0.022	0.56394	0.006	0.20377	0.379	0.24691	0.252	0.37360	0.137
lnrd	0.14888	0.233	0.16737	0.142	0.05578	0.633	-0.12790	0.240	-0.15516	0.130	-0.16412	0.128
lnRT	0.06830	0.266	0.04740	0.391	0.05552	0.309	0.29984	0.045	0.30196	0.030	0.19624	0.193
CE			0.00007	0.059					0.00004	0.072		
IM					0.00017	0.052					0.00009	0.125
cons.	3.48952	0.017	3.95192	0.005	2.96772	0.024	2.64966	0.207	2.26242	0.240	2.92066	0.148
Obs.	20		20		85		21		21		21	
Adj R^2	0.9811		0.9850		0.9852		0.9593		0.9662		0.9637	

Model	Ulsan						Jeonnam					
	3-1		3-2 (CE)		3-3 (IM)		4-1		4-2 (CE)		4-3 (IM)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
lnngd	-0.03214	0.385	-0.03205	0.413	-0.0497	0.332	-0.00246	0.881	0.00102	0.956	-0.00298	0.832
lnSk	-0.08748	0.274	-0.08526	0.352	-0.0772	0.363	-0.00685	0.948	-0.00253	0.982	0.00960	0.916
lnSh	0.03551	0.702	0.03839	0.723	0.0320	0.740	0.10288	0.561	0.08641	0.648	-0.03691	0.824
L1.lny	0.42537	0.006	0.42376	0.011	0.4243	0.009	0.58463	0.098	0.68316	0.116	1.00478	0.021
lnrd	-0.09467	0.216	-0.09299	0.275	-0.1101	0.198	-0.07754	0.745	-0.11614	0.660	-0.07136	0.726
lnRT	0.43838	0.016	0.42906	0.079	0.4428	0.020	0.26980	0.222	0.23209	0.340	0.06134	0.770
CE			0.000002	0.951					0.00008	0.626		
IM					0.00005	0.594					0.00039	0.084
cons.	-1.25251	0.697	-1.07771	0.807	-1.2818	0.702	-0.58289	0.846	-0.73102	0.818	-0.83596	0.745
Obs.	17		17		17		15		15		15	
Adj R^2	0.9551		0.9501		0.9517		0.9815		0.9796		0.9866	

Note: CE and IM respectively indicates the competitive effect and the industrial mix of the shift-share analysis in Chapter 6.

Figure 7-1 Results of testing for the multicollinearity with three models applied

Busan

. vif

Variable	VIF	1/VIF
lnRT	18.13	0.055169
lnrd	12.92	0.077375
lnSh	10.95	0.091323
lnSk	2.64	0.378480
lnngd	1.49	0.669593
Mean VIF	9.23	

. vif

Variable	VIF	1/VIF
lnRT	19.36	0.051666
lnrd	12.94	0.077265
lnSh	12.29	0.081358
lnSk	2.76	0.362410
lnngd	1.59	0.627899
CE	1.53	0.655458
Mean VIF	8.41	

. vif

Variable	VIF	1/VIF
lnRT	18.13	0.055163
lnrd	14.08	0.071044
lnSh	13.08	0.076462
lnSk	2.81	0.355492
lnngd	2.06	0.486474
IM	1.56	0.642983
Mean VIF	8.62	

Incheon

. vif

Variable	VIF	1/VIF
lnRT	8.01	0.124846
lnSk	4.79	0.208750
lnSh	3.42	0.292330
lnrd	2.18	0.459421
lnngd	1.35	0.738209
Mean VIF	3.95	

. vif

Variable	VIF	1/VIF
lnRT	8.06	0.124076
lnSk	5.08	0.196945
lnSh	4.02	0.248540
lnrd	2.21	0.452708
lnngd	1.82	0.548567
CE	1.57	0.638109
Mean VIF	3.79	

. vif

Variable	VIF	1/VIF
lnRT	8.49	0.117803
lnSk	4.87	0.205550
lnSh	3.55	0.281825
lnrd	2.19	0.455876
lnngd	1.65	0.604408
IM	1.29	0.775977
Mean VIF	3.67	

Ulsan

. vif

Variable	VIF	1/VIF
lnSh	18.45	0.054203
lnRT	11.94	0.083774
lny		
L1.	7.88	0.126946
lnSk	3.70	0.270476
lnngd	2.06	0.484571
lnrd	1.74	0.576279
Mean VIF	7.63	

. vif

Variable	VIF	1/VIF
lnSh	22.62	0.044202
lnRT	21.96	0.045527
lny		
L1.	8.17	0.122349
lnSk	4.40	0.227078
CE	2.50	0.399832
lnngd	2.07	0.483929
lnrd	1.95	0.513545
Mean VIF	9.10	

. vif

Variable	VIF	1/VIF
lnSh	18.53	0.053953
lnRT	11.97	0.083554
lny		
L1.	7.88	0.126915
lnSk	3.91	0.255914
lnngd	3.61	0.276849
IM	2.25	0.443661
lnrd	1.98	0.504877
Mean VIF	7.16	

Jeonnam

. vif

Variable	VIF	1/VIF
lnrd	19.13	0.052286
lnRT	18.81	0.053176
lnSk	1.24	0.808924
lnngd	1.09	0.913403
Mean VIF	10.07	

. vif

Variable	VIF	1/VIF
lnrd	19.14	0.052242
lnRT	18.81	0.053174
lnSk	1.39	0.720377
CE	1.31	0.760966
lnngd	1.27	0.786264
Mean VIF	8.38	

. vif

Variable	VIF	1/VIF
lnrd	20.66	0.048414
lnRT	20.33	0.049179
lnSk	1.29	0.773297
IM	1.22	0.816408
lnngd	1.10	0.909106
Mean VIF	8.92	

7.3.3 Post-estimation tests

As the first step in the post-estimation test, the multicollinearity test was conducted. This test starts from the model with six independent variables of *lnngd, lnSk, lnSh, L.lny, lnrd, lnRT* and expands by applying the model with the additional variable of *IM* and *CE* applied. An individual variable that has a great VIF was omitted in order when the mean VIF became less than 10. As a result, as shown in Figure 7-1, in the case of Busan and Incheon, the variable of the GVA per worker in previous period (*L.lny*) was removed since it has the largest VIF among the independent variables. On another hand, in the case of Ulsan, the original models meet the rule of thumb with the VIF of a high single digit. On the other hand, in the case of Jeonnam, the multicollinearity is so severe that the variables of *L.lny* and *lnSh* were left out.

As the second step, the tests for the residuals are following. As discussed in the previous chapter, the tests consist of the homoskedasticity test and the independence test. In order to conduct the two tests, this study applies the two-way scatters with the fitted values of the dependent variable and the residuals, as shown in Figure 7-2. At a glance, it can be concluded that the residuals have the same distribution centred on zero.

Figure 7-2 Two-way scatters of fitted values and residuals

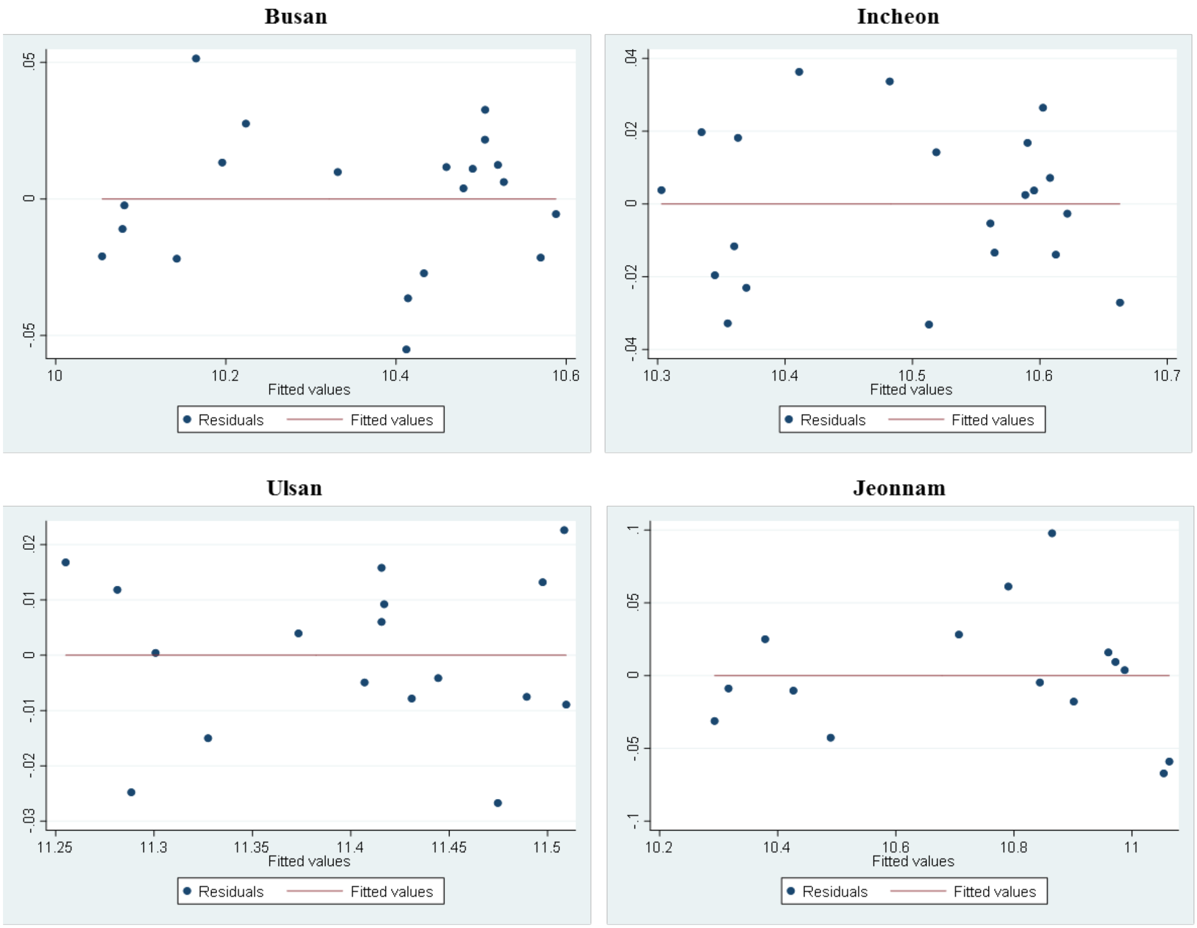


Figure 7-3 Two-way scatters of residuals and residuals in previous period

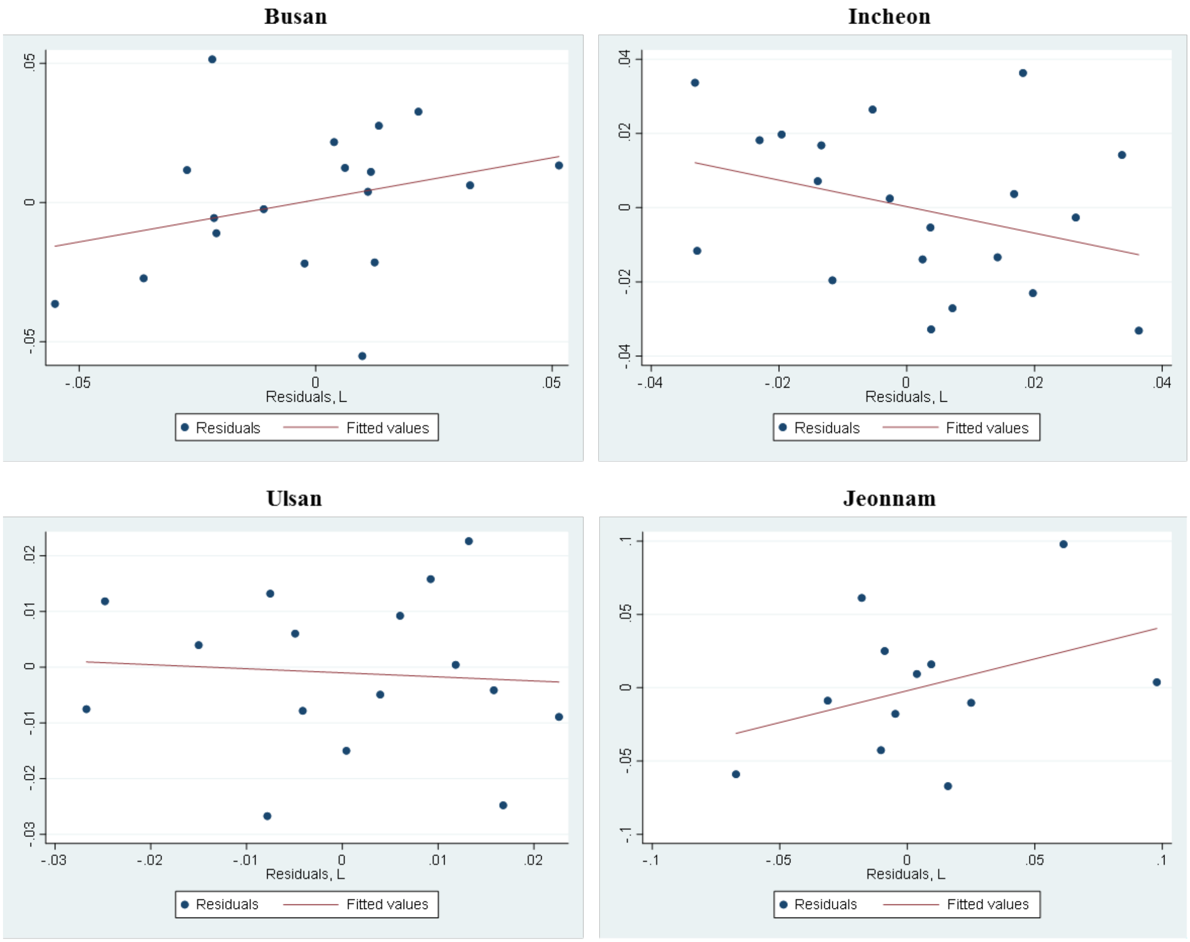


Table 7-5 Result of testing for auto-correlation of residuals

Region	Dep var	Indep var	coef.	p-value
Busan	ehatbusan	L.ehatbusan	0.3024	0.228
Incheon	ehatincheon	L.ehatincheon	-0.3570	0.141
Ulsan	ehatulsan	L.ehatulsan	-0.0730	0.781
Jeonnam	ehatjeonnam	L.ehatjeonnam	0.4339	0.210

On the other hand, the residuals appear to be statistically related with the ones in the previous period, as shown in Figure 7-3. In order to clarify the statistical relationship, this study regressed the residuals and the ones in the previous period respectively in the four regions, as shown in Table 7-5. As a result, this study confirms that the residuals are independent of each other since the t-tests in the four regions cannot reject the null hypothesis, which the residuals are independent each other, at the confidence level of 90%.

In conclusion, this study can estimate the parameters of the independent variables by applying the classical linear regression based on the assumptions with regard to the error terms.

Table 7-6 Results of estimating of parameters

Model	Busan						Incheon					
	1-1		1-2 (CE)		1-3 (IM)		2-1		2-2 (CE)		2-3 (IM)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
lnngd	0.00452	0.521	0.00766	0.258	0.00039	0.962	-0.01597	0.293	-0.00143	0.929	-0.02285	0.180
lnSk	0.03152	0.692	0.06064	0.419	0.01210	0.883	-0.14090	0.108	-0.17492	0.044	-0.13065	0.138
lnSh	0.19025	0.029	0.23884	0.008	0.22405	0.021	0.35630	0.000	0.38332	0.000	0.36365	0.000
L1.lny												
lnrd	0.31308	0.019	0.32093	0.011	0.27867	0.041	-0.10274	0.320	-0.12323	0.210	-0.11152	0.285
lnRT	0.13479	0.047	0.10618	0.092	0.13543	0.048	0.36626	0.006	0.38138	0.003	0.33850	0.012
CE			0.00007	0.074					0.00003	0.092		
IM					0.00010	0.345					0.00005	0.336
cons.	6.24662	0.000	6.54865	0.000	6.27781	0.000	3.36964	0.085	3.15027	0.086	3.87083	0.060
Obs.	20		20		20		21		21		21	
Adj R^2	0.9738		0.9781		0.9737		0.9598		0.9651		0.9598	

Model	Ulsan						Jeonnam					
	3-1		3-2 (CE)		3-3 (IM)		4-1		4-2 (CE)		4-3 (IM)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
lnngd	-0.03214	0.385	-0.03205	0.413	-0.0497	0.332	-0.00294	0.876	-0.00658	0.757	-0.00252	0.899
lnSk	-0.08748	0.274	-0.08526	0.352	-0.0772	0.363	-0.19745	0.020	-0.18507	0.044	-0.20256	0.027
lnSh	0.03551	0.702	0.03839	0.723	0.0320	0.740						
L1.lny	0.42537	0.006	0.42376	0.011	0.4243	0.009						
lnrd	-0.09467	0.216	-0.09299	0.275	-0.1101	0.198	0.31342	0.117	0.31603	0.131	0.33062	0.131
lnRT	0.43838	0.016	0.42906	0.079	0.4428	0.020	0.61069	0.005	0.61122	0.008	0.59439	0.011
CE			0.000002	0.951					-0.00008	0.647		
IM					0.00005	0.594					0.00007	0.758
cons.	-1.25251	0.697	-1.07771	0.807	-1.2818	0.702	-1.63865	0.525	-1.69657	0.529	-1.38270	0.625
Obs.	17		17		17		15		15		15	
Adj R^2	0.9551		0.9501		0.9517		0.9745		0.9723		0.9719	

7.3.4 Estimating parameters

The coefficients estimated after the post-estimation tests are shown in Table 7-6. Above all, in the case of Busan, the basic model (1-1) suggests that the coefficient of *lnRT* (0.135) is quite bigger than the one of 0.019 in the whole analysis in the previous chapter. However, it is not reasonable to interpret the two coefficients based on the same ground since the variable of GVA per worker in the previous period (*L.lny*) is left out in the analysis in this chapter. In fact, the coefficient of road density (*lnrd*), 0.313 in the regression by region, is almost 20 times as great as the one of 0.0153 in the whole analysis. On the other hand, applying the additional variable of *CE* (Model 1-2) appears to slightly increase the goodness of fit in the sight of adjusted R-square; from 0.9738 in Model 1-1 to 0.9781 in Model 1-2. In addition, the power of the model can be evaluated to get better as considering the p-values of the coefficients; for example, the p-values except for the one of *lnRT* appear to be more stable in Model 1-2 than in Model 1-1. However, applying the variable of *IM* (Model 1-3) does not supply any statistical difference from the basic model in the sights of both adjusted R-square and the t-tests of the coefficients. In conclusion, the increase of the port traffic contributes statistically to the growth of the Busan regional economy and the *CE* in transportation is quite useful to estimate the coefficients at the level of a regional economy. This conclusion is strongly consistent with the results that the CE is strongly correlate with the regional GVA per worker in Chapter 6 and the coefficient of *lnRT* is statistically significant in chapter 6.

Secondly, in the case of Incheon, the basic model (2-1) suggests that the coefficient of *lnRT* (0.366) is quite bigger than the one of 0.019 in the whole analysis. However, it is necessary of carefully interpreting the results due to the differences in the independent variables. On the other hand, the impact of applying additional variables is comprehensively similar to the one in the case of Busan. Firstly, the goodness of fit is better in Model 2-2, in which the adjusted R-square is 0.9651, than in Model 2-1, in which the adjusted R-square is 0.9598. In addition, the power of estimating the coefficients can be understood to increase when the variable of *CE* is applied but be similar when the variable of *IM* is applied. In conclusion, the increase of port traffic contributes statistically to the growth of the Incheon regional economy and the CE in transportation is quite useful to estimate the coefficients at the level of a regional economy.

Thirdly, in the case of Ulsan, the basic model (3-1), which consists of the same variables as the regression function in the previous chapter, implies that the coefficient of *lnRT* (0.438) is almost 20 times as great as the one of 0.019 in the whole analysis. As such, the result suggests that estimating the coefficient can show such a different relationship between the variable of *lnRT* and the growth of a regional economy according to the analysis methodology. On the other hand, applying additional variables does not increase the goodness of fit and the power of the t-tests for the coefficients. In fact, the goodness of fit is worse in Model 3-2, in which the adjusted R-square is 0.9501, and in Model 3-3, in which the adjusted R-square is 0.9517, than in Model 3-1, in which the adjusted R-square is 0.9551. In addition, the figures of the p-values are likely to get bigger when the additional variables of *CE* and *IM* are applied. In conclusion, the increase of port traffic has the much stronger statistical relationship with the growth of the Ulsan regional economy compared to the case of estimating the single coefficients for all regions and by several groups.

Lastly, in the case of Jeonnam, the basic model (3-1), which consists of four independent variables due to the multicollinearity, implies that the coefficient of *lnRT* (0.611) is quite big but the model cannot be regarded to supply the statistically significant results. Even though the adjusted R-square of 0.9745 is enough to be statistically significant, the model lost the key factor of the ratio of income invested in human capital (*lnSh*) and the coefficient of *lnRT* (0.611) is too huge to be reasonable. As a result, it is not natural to interpret the results of applying additional variables of CE and IM. In fact, the t-test for the coefficient of CE and IM implies not to be statistically significant. In conclusion, the results suggests some significant estimators in the sight of statistics but should be understood carefully due to the change in the independent variables.

Table 7-7 Result of testing for Granger causality of Busan

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT
lny	Coef.	0.6079	0.1345	-0.1003	0.1755	1.29	3.96	0.2742	0.0651
	S.E.	0.2319	0.2292	0.0884	0.0882				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnRT	L2.lnRT	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnRT	Coef.	0.8678	-0.2241	0.0335	0.7691	0.00	1.35	0.9607	0.263
	S.E.	0.2549	0.2544	0.6689	0.6613				

Table 7-8 Result of testing for Granger causality of Incheon

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT
lny	Coef.	0.8884	0.0469	-0.0699	0.0694	0.37	0.35	0.5526	0.5648
	S.E.	0.2702	0.2657	0.1151	0.1179				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnRT	L2.lnRT	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnRT	Coef.	0.2256	-0.2424	0.3572	0.5255	0.27	0.60	0.6134	0.4522
	S.E.	0.2949	0.3022	0.6924	0.6808				

Table 7-9 Result of testing for Granger causality of Ulsan

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnRT	L2.lnTR	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT
lny	Coef.	0.5169	0.2636	0.2409	-0.1353	1.69	0.64	0.2200	0.4421
	S.E.	0.2921	0.1816	0.1853	0.1696				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnRT	L2.lnRT	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnRT	Coef.	0.9055	-0.2396	-0.0313	0.3409	0.00	1.07	0.9539	0.3225
	S.E.	0.3357	0.3074	0.5293	0.3291				

Table 7-10 Result of testing for Granger causality of Jeonnam

Dependent variable		Independent variables				F statistic		p-value	
		L.lny	L2.lny	L.lnRT	L2.lnTR	L.lnRT	L2.lnRT	L.lnRT	L2.lnRT
lny	Coef.	0.6940	0.2742	0.0079	-0.0476	0.00	0.07	0.9629	0.7968
	S.E.	0.3042	0.2912	0.1664	0.1816				

Dependent variable		Independent variables				F statistic		p-value	
		L.lnRT	L2.lnRT	L.lny	L2.lny	L.lny	L2.lny	L.lny	L2.lny
lnRT	Coef.	0.6843	-0.2439	-0.2761	0.8265	0.30	2.91	0.5937	0.1088
	S.E.	0.2771	0.3023	0.5065	0.4848				

7.3.5 Test for the causality

As the last step of the econometric analysis, the Granger causality test between the dependent variable and an explanatory variable are conducted, as shown in Table 7-7, Table 7-8, Table 7-9 and Table 7-10. Above all, in the case of Busan, the test results, as shown in Table 7-7, show that the null hypothesis, which '*lnRT* does not cause *lny*', is rejected at the confidence level of 90% since the p-value of the F-test for the variable of *L2.lnRT* is 0.0651. However, the null hypothesis that '*lny* does not cause *lnRT*' is not rejected in the lower table. It means that the variable of *lnRT* has the Granger causality and the results above can be interpreted to be statistically significant.

On the contrary, in the case of Incheon, Ulsan and Jeonnam, the null hypotheses both that '*lnRT* does not cause *lny*' and that '*lny* does not cause *lnRT*' cannot be rejected at the confidence level of 90%, as shown in Table 7-8, Table 7-9 and Table 7-10. However, the Granger causality tests do not disaffirm the results of estimating parameters and the statistical relationship between the independent variables and the dependent variable, due to the feature of the Granger causality test as discussed in the previous chapter. Nevertheless, it is necessary that the results should be interpreted carefully; for example, the variable of *lnRT* has a statistically strong relationship with the growth of a regional economy rather than a great elasticity.

7.3.6 Summary

In this section, this study discusses the results of the econometric analysis by region as referring to the ones for the panel data in the previous chapter. As a first step, this study converts the regression function for the cross-sectional time-series data to for individual time-series data by region. Then, this study performs the regression for 16 regions and compares the estimators of the independent variables in 11 regions except for five inland regions. Thirdly, focused on the four major ports, this study introduces the results of regressing the variables and applying additional variables by region. In conclusion, in the case of Busan and Incheon, the regression supplies quite significant results that the variable of *lnRT* contributes to the growth of regional economies and that the additional variable of *CE* from the shift-share analysis is pretty helpful to understand the role of the individual ports. On another hand, in the case of Ulsan, the regression are significantly conducted to suggest the statistical relationship between the variable of *lnRT* and the variable of *lny*; however, applying additional variables of *CE* and *IM* does not supply any significant result. On the other hand, in the case of Jeonnam, the results does not suggest the elasticity of the variable of *lnRT* to the variable of *lny*: neither, applying additional variables is not statistically significant. Lastly, this study introduces the results of the Granger causality test by region; namely, the variable of *lnRT* has the Granger causality to the variable of *lny* in the case of Busan but does not have in the other three regions.

7.4 Findings

The application of the econometric analysis for the four port regions supplies so different results from the one for the panel data that they suggest some meaningful implications. In this section, this study summarises the key findings from the application of the econometric analysis in this chapter.

7.4.1 Different statistical relationship between variables

The correlation analyses for individual time-series data by region show that the coefficients are quite different from the one of the correlation analysis for the panel data in the previous chapter.[129] The estimators of the correlation analyses show such a different figure as shown in Table 6-2 and Table 7-2. In particular, the transport-related variables such as the GVA per worker in transportation (*yt*), road density (*rd*) and port traffics (*RT*, *TEUp* and *TEUr*) are analyzed to have much stronger correlation with the regional GVA per worker (*y*) compared to the ones of the correlation analysis with the panel data. Firstly, the statistical relationship between the GVA per worker in transportation and the regional GVA per worker is significantly different according to the structural characteristics of individual regional economies. For example, the correlation coefficients in port cities such as Busan and Incheon are quite great at 0.9 or more but the ones in inland cities such as Seoul and Daegu do not meet the critical value of 0.4329 at the confidence level of 95% in the two-tailed test.

Secondly, each region has such a different figure in the correlation coefficient between road density and the regional GVA per worker according to the characteristics of a regional economy. In the case of the analysis for the panel data, the correlation coefficient of -0.0114 is not statistically significant at the confidence level of 95%. However, the coefficients by region generally exceeds the critical value of 0.4329 in most of regions except for Seoul and Gyeonggi. Especially, the one in some regions like Busan and Jeonnam is greater than even 0.9.

Lastly, the correlation coefficient between the port traffic and the regional GVA per worker is very different from the one in the previous chapter. The single coefficient in the previous implies that the variable of port traffic measured by *RT* has a statistically significant relationship with the regional GVA per worker but the variables of port traffic by *TEU* do not have: specifically, the coefficient of *RT* is 0.5782, the one of *TEUp* is -0.0757 and the one of *TEUr* is -0.0151. However, the coefficients by region suggest that the variables of port traffic have a strong positive correlation with the growth of a regional economy: meanwhile, the variable of *RT* is more stable than the one of the others.

[129] The correlation analysis in chapter 7 estimates a single coefficient for each pair of variables with the entire panel data. Meanwhile, the correlation analyses in this chapter estimate 16 coefficients of each pair of variables by region. As a result, the critical value of the analyses in this chapter greatly get bigger as the observation and the degree of freedom greatly get smaller.

7.4.2 The implications of the estimated coefficients

This study examines the statistical relationship between the port traffic and a regional economy by applying the econometric analysis in chapter 6 and chapter 7. The results of estimating coefficients by applying various methods are shown in Table 7-11. This study implements the econometric analyses with three types of explanatory variables such as *lnRT*, *lnTEUp* and *lnTEUr*. In addition, three different regression for the panel data are applied: namely, the analysis for the whole panel data, the analyses with sub-periods and the ones with sub-regions. In addition, this study regresses the coefficients by region as applying the variable of *lnRT*. Based on the results from the various methods, this study summarises several conclusions as focusing on the estimated coefficients as follows. Firstly, the statistical relationship of a port with its regional economy is better explained by the variable of port traffic measured by *RT* rather than the one by *TEU*. This is supported by the fact that the R-square is generally greater in the model with *lnRT* applied than in the model with *lnTEUp* and *lnTEUr* applied.

Table 7-11 Comparison among the results by analytic methods

Data type	Analytic method		Explanatory variable			R-square
			variable	Coef.	p-value	
Panel data	whole		lnRT	0.0179	0.005	0.9769
			lnTEUp	0.0008	0.602	0.9651
			lnTEUr	0.0020	0.490	0.9653
	sub-period analysis	1994-2000	lnRT	0.1090	0.055	0.7427
			lnTEUp	0.0006	0.960	0.4662
			lnTEUr	0.0006	0.960	0.4662
		2001-2008	lnRT	0.0209	0.244	0.9534
			lnTEUp	-0.0003	0.957	0.9375
			lnTEUr	-0.0003	0.957	0.9375
		2009-2015	lnRT	0.0512	0.072	0.7415
			lnTEUp	0.0074	0.016	0.7325
			lnTEUr	0.0043	0.134	0.7271
	Sub-region analysis	without	lnRT	0.0095	0.576	0.9723
			lnTEUp	-0.0005	0.732	0.9512
			lnTEUr	0.0013	0.704	0.9412
		with	lnRT	0.0674	0.004	0.9745
			lnTEUp	0.0392	0.030	0.9670
			lnTEUr	0.0212	0.073	0.9618
Time-series data by region	Busan		lnRT	0.1348	0.047	0.9738
	Incheon		lnRT	0.3663	0.006	0.9598
	Ulsan		lnRT	0.4384	0.016	0.9551
	Jeonnam		lnRT	0.6107	0.005	0.9745

Secondly, the statistical relationship between the port traffic and a regional economy has changed rapidly over time. For example, the coefficient of *lnRT* (0.109) was very significant and stable in the 1990s, but the one of 0.0209 in the 2000s was not significant at the confidence level of 90%. However, in the case of the 2010s, the coefficient of *lnRT* (0.0512) is significant at the confidence level of 90% and the one of *lnTEUp* (0.0074) is significant at the confidence level of 95%. These changes can be understood that the economic contribution of the ports to the regional economies have decreased over time under the influence of the structural changes in transportation in the national economy and the regional economies.

Lastly, it is suggested that how much the port traffic contributes to the growth of a regional economy can be different according to the features of individual ports such as the volume of port traffic and the cargo type composition. Specifically, some regions with large ports whose coefficient is 0.0674 get much more economic benefits from the port-related activities than the regions without large ports whose coefficient is 0.0095. In conclusion, it is recommended to take into account of the contextual features both of port-related activities and of the regional economy when port research analyses the statistical relationship of them by applying the econometric analysis. With regard to this, this study discusses further below.

7.4.3 The features of research methodology

Understanding the features of each econometric analysis applied in chapters 6 and 7 is quite helpful to interpret the results of the analysis better. Each approach has various characteristics that are introduced in the previous chapters, as shown in Table 7-12. As well, it is expected that understanding the analytic method better can play a role as a significant guideline for selecting an appropriate methodology with regard to applied research including port studies.

Table 7-12 Comparison of the features among analytic methods

Analytic type		Features	Note
Cross-sectional time-series data (Panel data)	Whole analysis	Data: homogenous or weakly heterogenous Intuition: same slope and different constant Estimation: one slope for regions	Strength: greater observation, stability Drawback: high risk of underestimation or overestimation in case of heterogenous data
	Sub-period analysis	Data: strongly heterogenous over time Intuition: slope and constant change over time Estimation: one slope by sub-period	Strength: moderate observation, estimating the changes over time Drawback: arbitrary in setting the criteria
	Sub-region analysis	Data: strongly heterogenous by region Intuition: slope and constant change by port size Estimation: same slope within a group	Strength: moderate observation, separating heterogenous regions Drawback: arbitrary in setting the criteria
Time-series data by region		Data: heterogenous over time & by region Intuition: different slope and constant by region Estimation: one slope for each region	Strength: showing each regional feature Drawback: smaller observation, very weak of data lose and statistically unstable

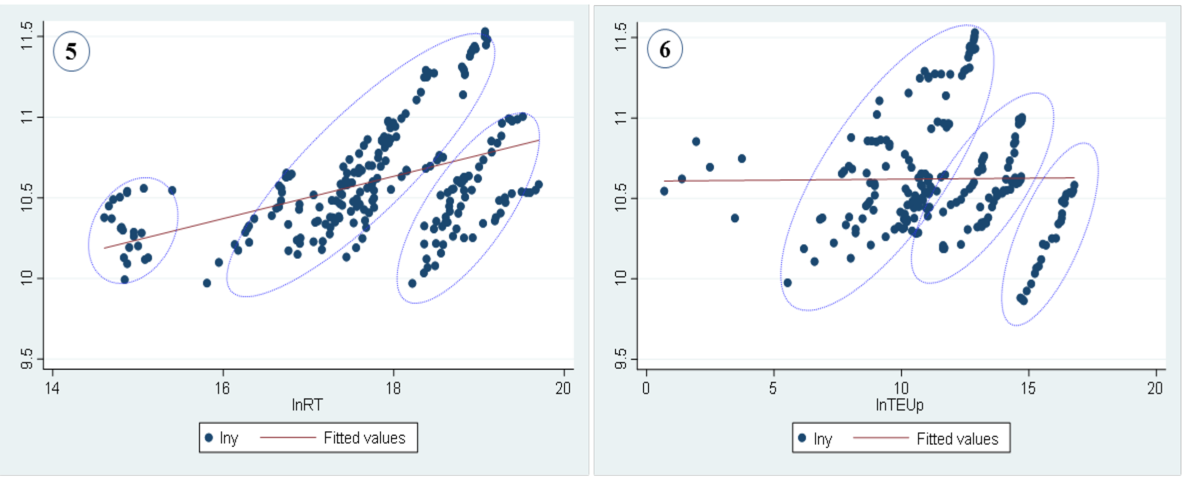
Note: compiled by the author based on Hsiao (2014), Wooldridge (2010) and Baltagi (2008).

The econometric analysis for the panel data is based on the implicit assumption that all panels in individuals or regions do not have strong heterogeneity (Hsiao, 2014); as such, a single coefficient for the entire regions can be estimated as the best linear unbiased estimator (BLUE). As well, this is why the econometric analysis for the panel data began to be applied in microeconomics in order to check the changes within an individual or a household (Baltagi, 2008). However, in the sight of regional economics or macroeconomics, it may be a strict assumption that all regional economies are homogenous or weakly heterogeneous, if considering that each regional economy even in a country has a unique industrial structure. This study discussed the structural features of transportation in the four major port regions in chapter 5. As considering the features, this study selected the fixed effect model for the panel data and interpreted the results from the econometric analysis in chapter 6.

As a result, this study introduces sub-groups in the econometric analysis to split the groups with different statistical relationship as considering the factor that brings the heterogeneity to the panel data. For example, the two-way scatters of port traffic (*lnRT* and *lnTEUp*) and the growth of regional eocnomies (*lny*) are shown in Figure 7-4. The figure is the part of Figure 6-1. Both two-way graphs with *lnRT* and *lnTEUp* applied imply that estimating of a single coefficient (line in red) can be inappropriate as a representative of the statistical relationship between port traffic and regional economic growth as considering scattered plots. As well, this study shows that the regression analysis for individual regions can better reflect the economic characteristics of each region, even though it has some drawbacks that the analysis can be statistically unstable as the observations are small and some data are lost in the process of transferring to a logarithmic variable.

In conclusion, this study shows that the sub-group analyses can enhance the power of the regression model compared to the analysis for the whole panel data. Furthermore, this study suggests that the researcher can intuitively decide which method is better as considering the nature of heterogeneity or the features of regional economies.

Figure 7-4 Two-way scatters of port traffic (*lnRT* and *lnTEUp*) and economic growth (*lny*)



7.4.4 The implications with regard to port studies and port policies

What is mainly discussed in this section has critical implications for port research and port policies. Firstly, this study suggests that the choice of an explanatory variable is necessary to be careful: especially, in the application of the econometric analysis in port studies and in the interpretation of the results. According to the results of the shift-share analysis in chapter 6, the GVA per worker in transport is likely to be higher in the regions where ports have a higher proportion of container cargo of total volume than in other regions. This is in line with recent port studies; so-called, the competition and/or the cooperation among ports (Song and Panayides, 2008, Slack, 2006, Song, 2003), the port regionalization (Notteboom and Rodrigue, 2005, Monios and Wilmsmeier, 2012a), and the port-centric logistics (Pettit and Beresford, 2009, Mangan et al., 2008), etc. In common, they stress that the value-added activities are gathered and agglomerated inside or around the district of container-driven ports. Furthermore, the phenomenon is likely to be intensified by the way that the port-related activities are vertically integrated with the forward and backward linked activities such as shipping, activities related the distribution centres and inland transportation, and spatially enlarged. However, according to the results in the previous chapter, it seems that the variable of port traffic measured by RT is more strongly related to the growth of a regional economy than the one by TEU. As a result, the contradictory results are understood to mean that the variable of *lnRT* is more statistically related to the growth of a regional economy rather than the variable of *lnTEUp* and lnTEUr but not that the variable of *lnRT* contributes more to the growth of a regional economy. This interpretation is quite reasonable as considering the service scope for each cargo type examined in chapter 5.

Secondly, different coefficient estimators between the regions with large ports and the regions without large ports imply that the economic impacts of the ports may be influenced by the size of a port and/or the amount of port traffics. As well, the relationship of port-related activities with other ones in the supply chains can be understood to influence the economic impact of the ports on its regions as considering the fact that the cargo type composition affects the service boundary and the GVA per worker in transportation as discussed in chapter 5 and chapter 6. As a result, the regions with large ports and the ones without large port have a different relationship with the regional economy. In other words, this implies that there can be the risk of underestimation or overestimation in port studies which estimate a single coefficient for all regions but do not properly consider the characteristics of each port and its regional economy. In the sight of port policy, this means that assessing of the economic effects of ports with the same criteria applied can also lead to distorted results.

Finally, analysing the economic impact of the ports on the regional economies requires a different approach from the one at the level of the national economy. At the level of the national economy, the risk of the biased estimation rooted in the size of a port or the industrial structure of the regional economies may not be serious due to the aggregation effect. However, the results of the estimation at the level of a regional economy might be quite different according to the characteristics of the regional economy as discussed in the previous sub-section. From this point of view, applying the inter-industry linkage derived at the level of the national economy directly to the estimation at the level of a regional economy may pose a serious risk of causing distorted results

Chapter 8 Conclusion

8.1 Overview

Economic impacts in port studies have experienced a steady and increasing interest from various stakeholders for various reasons (Dooms et al., 2015). However, the main body of the PISs have focused on estimating the economic effects by the value for money at a specific time period by applying IO tables (Coppens et al., 2007) or analysing the statistical relationship between port activities and some variables in the regional economies (Ducruet, 2011). In recent decades, a few PISs have proposed the statistical significance of the regional economic effects of ports by using the panel data gathered from the regional accounts (Shan et al., 2014, Park and Seo, 2016). Nevertheless, these studies applying various methodologies have a common limitation in that they cannot provide sufficient information with regard to the changes in the relationship between port-related activities and the growth of regional economies over time.

Despite the efforts, the PISs still face the criticism such as the lack of a consensus on the methodology and the over-estimation (Dooms et al., 2015, Davis, 1983) and the research gaps between port studies and the PISs. In the methodological aspect, the PISs have generally been in the debates with regard to both what the port-related activities are and what extent the economic impact of ports are (Benacchio and Musso, 2001). On the other hand, in recent decades, the PISs has been requested to fill the research gap with regard to the impact of the surrounding changes on the port-related activities: especially, the economic impact of the intensification of the functional integration and the spatial enlargement. This is why a longitudinal understanding is getting more important as more of the port-related activities have been embedded in the logistics networks (Bottasso et al., 2013). Nevertheless, the econometric analysis has a drawback not to reflect the functional changes of the port-related activities. Furthermore, it is not easy to find port studies that have interests in understanding what economic effect the surrounding changes have brought in the regional economies, even though a huge body of port studies have stressed the influence of the surrounding changes on the port-related activities (Notteboom and Rodrigue, 2005, Monios and Wilmsmeier, 2012a).

In order to mitigate these research gaps, this study conducts empirical studies by applying a multi-methodology approach, as shown in Table 8-1. Firstly, in chapter 3, this study discusses the development trajectory of the four major ports and their status in the national port system. As well, this study supplies the commonalities and the differences between the four ports. As a result, this study suggests that the four ports have their own footprint in relation with the national economy and their regions.

Table 8-1 Comparison of key features among four empirical analyses

Chapter	Locus	Viewpoint	Method	Key findings
3	Port	Changes in the spatial scope and the functional role in port systems	Topological, Quantitative	Individual port has its own footprint in relation to both the national economy and the regional urbarnization.
5	Transportation in regional economies	Changes in the GVA over time and structural change	Shift-share, Correlation	Transport nodes has played the key role of making the disparity in the GVA per worker of transportation between regions.
6	Regional economy	Statistical relationship between port variables and a regional economy	Econometric (whole vs sub-groups)	Ports have the statistically valid relationship with the growth with regional economies. The extent and the elasticity is quite different according to the period and the size of a port.
7	Regional economy	Statistical relationship between port variables and a regional economy	Econometric (individual)	Estimating a single coefficient for many regions can derive the biased result. Port studies should consider the qualitative features of ports.

In chapter 5, this study examines what the status of transportation has been over time as an industry in the regional economy by applying the descriptive analysis, the shift-share analysis and the correlation analysis. In particular, this study classifies the features of transportation in the four regional economies through analysing the annual changes in the GVA per worker of the four sub-sectors in transportation. In conclusion, this study suggests that the transport node as seaports has a great influence on the regional difference and the annual changes in the GVA per worker of transportation.

In chapter 6, this study supplies the results of the econometric analyses and the comparative results of three different analyses with regard to the statistical relationship between the port traffic and the growth of the regional economies. Especially, this study introduced the sub-period analysis: 1994-2000, 2001-2008, and 2009-2015, and the sub-group analysis: the regions with large ports and the regions without large ports. As a result, this study proposes that the economic effect of the four ports on the regional economies are statistically valid but the extent in elasticity of regional economic growth to port traffic can be considerably different according to the size of port traffic and the qualitative features of the ports.

Lastly, in chapter 7, this study conducts the application of the econometric analysis by an individual region for connecting the shift-share analysis in chapter 5 and the econometric analysis in chapter 6. As a result, this study makes it clear that estimating of a single coefficient with the panel data used may result in over-estimation or under-estimation of the economic effects of the ports. Also, to minimize these risks, this study suggests that the qualitative features of the regional economies and the port-related activities should be considered as a prerequisite of the econometric analysis.

8.2 Main Conclusions

This study aims to clarify the significant implication that the intensification of the functional integration and the spatial enlargement is likely to expand the economic disparity in transportation between the port cities in the sight of the impacts of the ports on its regional economies. The objective can be evaluated in detail by revisiting the research questions in chapter 4.

- How can an empirical study examine whether the structural changes in the port studies took place in practice or not?
- How can the PIS show what economic impact the changes have brought in the statistics?
- What methodologies can efficiently show the changes and the impacts both at the national level and at the regional level?
- Are the answers for the above able to be supplied with the data from regions accounts applied?

For answering the first question and the second one, this study applies the three different approaches, as shown in Table 8-1. Firstly, at the level of port, this study shows that individual ports have their own footprint in the sight of port development trajectory, the interaction with the city and their role in the national ports systems. Secondly, at the level of transportation, this study shows that individual port cities have quite different status of transportation in terms of the GVA per worker and the proportion of transportation in the regional economies. In particular, the ports of Busan and Incheon, where containerized freight makes up higher proportion of the port traffic, make a greater contribution to their regional economies. The originality of this thesis rests in showing if the suggestions in the port studies take place in practice by applying the shift-share analysis and if this methodology is useful in examining the structural changes of four sub-sectors in transportation for the first time. Lastly, at the level of a regional economy, this study implies that the economic impact of individual ports is quite different according to the size of port traffic, the cargo composition and the spatial boundary of the users etc.

With regard to the third one and the fourth one, this study suggest several significant implications in the sight of the PISs. The ports, which supply the various services to connect other activities in transportation and even to support the chain management of manufacturing corporations, have quite different sectoral structures of transportation in the regional economies.[130] In other words, the extent of the functional integration of the port-related activities influence the capability to generate the GVA per worker of transportation and the sectoral composition of the four sub-sectors in transportation. In addition, these differences in transportation between regions may exaggerate the difference between the regional economies so that some economic-based methodologies can derive some distorted results. In other words, some significant biases in the PISs can result from the incorrect

[130] These ports generally have a container freight centred cargo composition.

application of the methodologies such as the IO analysis of using the national IO tables and the econometric analysis of estimating a single coefficient for the whole country. Furthermore, the bias may get larger when the features of individual ports are not carefully taken into consideration. These are due to the methodological characteristic that they are based on the implicit assumption that each regional economy has the same or a similar structure as the national economy.

In this section, this study unfolds the main conclusion in the several detailed findings as following the order of the empirical analyses.

8.2.1 Specified footprint at the level of a port

This study implements the historical review and the spatial analysis of the four major ports with the port development trajectory focused. Then, this study suggests the key findings by comparing and understanding the commonalities and the differences among the four ports.

8.2.1.1 Port development trajectory

In the historical aspect, the four ports have such a different feature as an international port. On one hand, both the Port of Busan and the Port of Incheon have been developed as a commercial port since the opening of the late 19th century rooted in the birthplace as a fishing port. On the other hand, the Port of Ulsan and the Port of Gwangyang have been developed as an industrial port, mainly supporting coastal industrial complexes nearby the port since the 1960s. As a result, the first two ports have developed as a modern port for a longer time period so that the port development has been conducted gradually but the last two ports have a tendency to be developed simultaneously.

Secondly, from the perspective of the port development model, the four ports clearly have followed quite different paths. On one hand, both the Port of Busan and the Port of Incheon as a commercial port have followed the classical three-stage development model of settlement, expansion, and specialization. Meanwhile, the Port of Busan and the Port of Incheon have undergone the different stage since the 2000s when the New Port opened. Namely, the Port of Busan has been in the new additional stage of ‘new port’ but the Port of Incheon is still in the third stage of ‘specialization’. On the other hand, the Port of Ulsan and the Port of Gwangyang began to be developed in earnest in the 1960s as an industrial port that functions mainly to support the demand generated in the industrial zone nearby the ports. For this reason, the two ports have had the different development trajectory that the second stage of ‘expansion’ and the third phase of ‘specialization’ proceed at the same time. This happened mainly since the two ports have been developed under the control of the plan of specializing the facilities by cargo type.

Lastly, in the topographical sight, the four ports have clearly been under the influence of the locational characteristics in the settlement. On one hand, the Port of Busan and the Port of Incheon have developed new port facilities spatially disconnected with the existing ones while constructing additional facilities at the coastal area far from the existing port facilities. On another hand, the Port of Ulsan has the features as a river port and an estuary port. The Port of Ulsan has expanded its spatial boundary gradually from the existing facilities alongside the Taehwa River to the estuary. On the other hand, the Port of Gwangyang has the unique characteristics in the topographic sight. The port is located inside of such a huge bay so that the additional facilities have been developed by the way of expanding the existing facilities at the different coastal areas.

8.2.1.2 Interaction with the city

This study briefly looks at the evolution procedure of the relationship between the port and the city. As a result, this study proposes that the four ports had such a different starting point and have followed the unique path as the effects of the co-operative and/or conflicting relationship between the port and the city. On one hand, in the spatial perspective, the four ports have the quite different interface with the urbanized area in the size and in the relationship as shown in Figure 3-9. Both the Port of Busan and the Port of Incheon have been directly surrounded by a large-scale interface with their urban areas. However, the Port of Ulsan and the Port of Gwangyang have been blocked by the coastal industrial complexes so that indirectly have the interface with the urbanized area through the industrial zone.

On the other hand, in the relational sight, the four ports have interacted with their cities continuously but in the different relationship over time as shown in Figure 3-10. The Port of Busan and the Port of Incheon have contributed to the spatial enlargement and the economic growth of the city as an engine to play various roles such as providing jobs, attracting population influx, and supplying various urbanized infrastructures. However, the port and the city have been in the heavy conflicting, centred on the existing port districts, such as road congestion, shortage of space, and environmental pollution through passing the stage of 'expansion'. The development of facilities in the New Port has been based on the cooperative and/or conflicting relationships at the same time. On the contrary, the Port of Ulsan and the Port of Gwangyang have a relatively weak and indirect relationship with their cities. This is due to the functional role of the port, mainly focusing on handling the raw materials and the intermediate goods and the products generated in the industrial complexes nearby the port district.

8.2.1.3 Status in the port system

This study shows that the four ports have a distinct difference in the perspectives of the cargo composition and the service boundary, even though they have a commonality of handling port traffic more than 100 million RT. In the aspect of the cargo composition as shown in Figure 3-12, Figure 3-13 and Figure 3-14, container freights that handle the intermediate goods and the products and is classified in 'others' account for higher proportion in the Port of Busan (83%) and the Port of Incheon (36%). However, the raw materials such as crude oil and iron ore is located in the first proposition, at least 70%, in the Port of Ulsan and the Port of Gwangyang. It is natural as considering the objective of developing of individual ports.On the other hand, in the sight of the service boundary as shown in Figure 3-16, the Port of Busan and the Port of Incheon depends mainly on the cargos generated outside of the port city: especially, 7.05% in Busan. Meanwhile, the Port of Ulsan and the Port of Gwangyang have a very high proportion of the cargos originated in nearby industrial complexes: respectively, 92.51% in Ulsan and Gyeongnam and 66.89% in Jeonnam. This considerable feature was influenced by the functional role of each port like a commercial or industrial port and the cargo composition; mainly, the ratio of container freight.

In conclusion, this study suggests that the four major ports have quite a different role and status in the national port systems. In the sight of the service boundary, the Port of Busan and the Port of Gwangyang has supplied the service to all over the country even though more than two-thirds of the total volume is concentrated in several administrative regions close to the port. Meanwhile, the Port of Incheon and the Port of Ulsan have played their role as a local or regional entry to cover adjacent regions. In the sight of the amount of container freights, the Port of Busan maintains its status to serve all over the country as the gateway port in South Korea, while the Port of Incheon and the Port of Ulsan plays as the entry for the economic zone nearby the port. One the other hand, the Port of Gwangyang is interpreted to play mainly as an entry port of the economic zone nearby the port and partly as an auxiliary gateway in South Korea.

8.2.1.4 Implications

The conclusions above suggest the implication that each port has a unique status in the port system and has the inherent feature beyond the port-based statistics such as the capacity of facilities, ship calling, and even port cargo traffic etc. (Ducruet, 2011). As well, they strongly suggest that an understanding of individual ports should be conducted sufficiently as a background for analysing the economic effects of the port on the regional economy. Especially, it is the cargo type composition and the functional role of the ports that may be the key factors of influencing the functional and spatial extent of the economic effects.

8.2.2 Different status of transportation in a regional economy

This study describes the sectoral status and the regional proportion that transportation has accounted for in the Korean economy over time by analysing the GVA per worker. In addition, this study overviews the sub-sectoral structure of transportation in the regional economies. Then, this study discusses the difference that the GVA per worker of transportation and the proportion of transportation in the 16 regional economies have shown over time and by region. In conclusion, transportation nodes such as ports and logistics centres have contributed to exaggerating the difference in the GVA per worker of transportation between regions and even in the proportion of the four sub-sectors. More detailed findings follow as below.

8.2.2.1 Status of regional transportation

In the longitudinal aspect, the status of transportation in a regional economy has changed continuously and drastically, as shown in Figure 5-4. In the early 1990s, the difference in the sectoral share of transportation in the 16 regional economies was not huge and seemed to result mainly from the presence and the extent of the urbanization and/or industrialization.[131] However, after the early 2000s, the regional disparity has increased gradually in both the GVA per worker in transportation and the sectoral proportion of transportation in a regional economy. Especially, the difference seems to be mainly under influence of the transport node such as a large-scale seaport and/or logistics centres rather than the extent of the urbanization and the industrialization.

On the other hand, in the aspect of regional disparity in 2015, the status of transportation is classified by the amount of the GVA per worker in transportation and the sectoral proportion of transportation as shown in Table 5-1. As a result, Incheon and Busan have both the high proportion and great GVA per worker; 13.39% and 5.57 million KRW in Incheon and 7.84% and 3.09 million KRW in Busan, so that those regions can be evaluated to supply transport services for the demands generated outside the administrative boundary. On the contrary, the inland cities and regions such as Seoul, Daegu, and Gwangju record quite lower position in the proportion and the amount; 3.16% and 1.82 million KRW in Seoul and 3.5% and 1.18 million KRW in Daegu. It means that the inland regions are likely to depend on transport service supplier outside their administrative boundary. In this context, Jeonnam (4.06%, 2.44 million KRW) and Jeju (5.91%, 2.25 million KRW) are said to supply the transport services to other regions and have the considerable amount of influx in the GVA per worker in transportation. Meanwhile, Ulsan is understood to create huge GVA per worker in transportation (2.57%, 2.54 million KRW), mainly depending on the incredible growth of the regional manufacturing companies, but has experienced the significant outflow to use the transport service suppliers outside the region.

[131] It was likely to be decided whether a region was urbanized or not in 1990. In other words, the metropolitan cities generally had greater GVA per worker in transportation and sectoral proportion of transportation than the provinces. However, through the 1990s, the factors to influence the status may have changed considering the status of transportation in Busan and Ulsan outlay in 2000. Furthermore, the factors have been more influential through the 2000s.

8.2.2.2 Changes in the GVA per worker of transportation

In the longitudinal sight, transportation in the four port regions has experienced a quite different growth pattern in the annual GVA per worker as shown in Figure 5-15. Especially, the GVA per worker of transportation in Busan, Incheon, and Jeonnam skyrocketed in the mid-1990s, the early 2000s, and the late 2000s respectively. After then, the GVA per worker of transportation has a tendency to converge to the changes in the national transportation. On the contrary, the one in Ulsan had decreased in the early and mid-2000s and fluctuated in the 2010s.

Secondly, the changes in the GVA per worker in the four regions have been significantly different from the growth rate of the national economy and the growth rate of the national transportation as shown in Figure 5-15. Especially, the changes are too huge to result from the overall growth of the national economy and/or the structural changes in the national transportation. As a result, the changes in the GVA per worker in each region is reasonable to understand the result of reflecting some characteristics rooted in individual regions such as the presence of transportation nodes such as a large-scaled seaport and the agglomerated logistics centres.

Lastly, the difference in the GVA per worker of the four sub-sectors in transportation is more noticeable as shown in Figure 5-16 In the case of Busan, while the GVA per worker in land transport has been in the decreasing trend from 2,011 thousand KRW in 2000 to 1,630 thousand KRW in 2015, transport supporting activities and maritime transport have experienced in the large growth; from 444 thousand KRW and 178 thousand KRW in 2000 to 877 thousand KRW and 586 thousand KRW respectively in 2015. This pattern is similarly observed in Ulsan. However, in the case of Incheon, the growth of transport supporting activities is outstanding from 269 thousand KRW in 2000 to 3,064 thousand KRW in 2015. As a result, transport supporting activities have overtaken land transport in the sectoral proportion and occupies the largest share of 55.0%, even though the latter has been in the steady growth and its share is 41.91%. In the case of Jeonnam, land transport, transport supporting activities and water transport have grown, even though the first two sub-sectors had a drop in the late 2000s.

8.2.2.3 Implications

The conclusions suggest several implications. Firstly, it can be evaluated that the presence of a large-scale port influenced considerably on the annual changes in the GVA per worker of transportation, even though the proportion of the port-related activities in transportation is quite small. This interpretation is supported by the results of the application of the econometric analysis by sub-region: the regions with large ports, which are handling port traffic more than 80 million RT, and the regions without large ports. Secondly, it can be said that the results correspond to the mainstream in port studies that the port-related activities have been in the progress of the functional integration with other activities in the logistics network and the spatial enlargement of the port-related activities: especially, value-added activities in the logistics centres such as repackaging, labelling, and even assembling as a precedent activity for the manufacturing. Lastly, the results imply that it is necessary to take into consideration of the qualitative features of the port-related activities such as the cargo composition and the service boundary as well as the cargo traffic when analysing the economic impact of ports with port traffics applied.

8.2.3 Contribution to a regional economy

This study shows that the 16 regions have the quite specialized characteristics in the sight of the industrial structure by applying the historical review of the port development trajectories and the shift-share analysis of the changes in the GVA per worker. This implies that the homogeneity or weak heterogeneity that is the implicit assumption of the econometric analysis may be violated in reality. Thus, this study has rigorously verified whether the panel data has any inter-regional dependence and whether the residuals violate the assumptions. In addition, the results of the econometric analysis are interpreted while considering the heterogeneity in the industrial structure. The main conclusions are comprised as follows.

8.2.3.1 Estimating of a single coefficient

In the sight of the goodness of fit, as shown in Table 6-8 , this study suggests that the model in which the variable of *lnRT* is added as an explanatory variable is superior to the models in which the variables of *lnTEUp* and *lnTEUr* are applied. This suggestion is supported by the fact that the R-square of 0.9769 is slightly higher in the model with *lnRT* than the one of 0.9651 in the model with *lnTEUp* and *lnTEUr* and that the t-tests of the coefficients are more significant in the former than in the latter. In addition, the coefficient of an explanatory variable is estimated 0.0179, significant at the confidence level of 99%, in the model of lnRT applied, whilst the one is estimated 0.0008 in the model *lnTEUp* applied and 0.002 in the model with *lnTEUr* applied; the last two estimators are not significant at the confidence level of 90%. This suggests that the port traffic measured by RT has a stronger statistical relationship with the regional GVA per worker than the port traffic measured by TEU since the former has comparatively smaller disparities between regions and more stable statistically. However, it does not mean that bulk cargo contributes much more to the growth of a regional economy.

8.2.3.2 Estimating of coefficients by group

The sub-group analyses supply some implications. Firstly, based on Table 6-9, Table 6-10 and Table 6-11, this study suggests that the economic contribution of the four major ports on the regional economy has decreased gradually decade by decade. This is supported by the estimators of the relationship between the port traffic and the growth of regional economies: specifically, in the model with *lnRT* applied, the coefficient of 0.109 in the first sub-period and the coefficient of 0.0512 in the third sub-period.[132] On the other hand, the results suggest that the power of the econometric analysis decreases significantly: in fact, even worse than what the author expected, even considering the decrease of the observations and the degrees of freedom. In the different point of view, the results suggest that there is still such a huge difference in the values of panels by a region.

Secondly, the results of the sub-region analysis supply some interesting implications as shown in Table 6-12 and Table 6-13. Above all, this study suggests that the regions with large ports have the greater coefficient of an explanatory variable (*lnRT, lnTEUp* and *lnTEUr*) with respect to the growth of a regional economy (*lny*), regardless of the explanatory variable. In the case of the model with *lnRT* applied, the coefficient of *lnRT* is estimated 0.0095 in the regions without large ports but 0.0674 in the regions with large ports[133]; in addition, the latter estimator is much greater than 0.0179 in the all regions. The features of the estimators are exactly same in the case of the models with *lnTEUp* (-0.0005 vs 0.0392) and *lnTEUr* (0.0013 vs 0.0212) applied. These results are exactly in line with the intuition that the ports with large port traffic may contribute to the regional economy much more than the ones with small port traffic. Secondly, the coefficient estimators of *lnRT*, *lnTEUp* and *lnTEUr* in the regions with large ports are statistically significant at the confidence level of 99%, 95% and 90% respectively. However, the power of the model in the case of the regions without large ports is not so good that the estimators are insignificant at the confidence level of 90%. Lastly, the results above propose that estimating a single coefficient can supply biased results of underestimating and/or overestimating the statistical relationship between the ports and the regional economies unless carefully considering the heterogeneous features of port-related activities and transportation. In other words, the economic impacts of the large ports may be underestimated but the ones of the small ports may be overestimated by the average effect when the whole ports are analysed together.

8.2.3.3 Estimating a coefficient by region

Focused on the four major ports, this study introduces the results of regressing the variables and applying additional variables by region as shown in Table 7-6. The coefficient of *lnRT* is estimated respectively 0.1348 in Busan, 0.3662 in Incheon, 0.4383 in Ulsan and 0.6106 in Jeonnam. In addition, the coefficient of *CE* and *IM* can be estimated significantly and be useful to increase the goodness of fit in the regression by region. However, the coefficients are carefully interpreted since they are

[132] The two coefficients are significant at the confidence level of 90%.
[133] The former is not significant at the confidence level of 90% but the latter is significant at the confidence level of 99%.

estimated by applying slightly different models in the sight of the independent variables.[134] For this reason, it is not reasonable to understand the results in the four regions based on the same ground.

In the case of Busan and Incheon, the regression supplies the significant result that the variable of *lnRT* contributes to the growth of regional economies and that the additional variable of *CE* from the shift-share analysis is helpful to understand the role of the individual ports. On another hand, in the case of Ulsan, the regression suggests that the statistical relationship between the variables of *lnRT* and *lny* is significant. However, applying additional variables of *CE* and *IM* does not supply any significant result. On the other hand, in the case of Jeonnam, the results suggest that the variable of *lnRT* is not significant to the variable of *lny* nor applying additional variables is.

8.2.3.3 Implications

The above results give the implications to the port studies from the theoretical point of view. Firstly, the results are interpreted to correspond that the port-related activities have been in the progress of the intensification of the functional connection and/or integration with various logistics activities: especially, value-added activities in the logistics centres. This can be supported by the finding of the sub-region analysis, in which the regions with large ports have much greater coefficients of an explanatory variable than the regions without large ports, as well as the result of the shift-share analysis, in which the greater GVA per worker of transportation is generated in the ports with the higher proportion of container freight.

On the other hand, the results imply that the PISs should considerably reflect the differences in terms of the sectoral structure in transportation and the ratio of transportation in the regional economies when estimating the coefficients of the independent variables. In the econometric analysis, the considerably different values are generally regarded as an outlier (Baltagi, 2008) so that some economic effects such as scale and scope of economy and agglomeration effect may not be reflected in the estimators. In other words, the PISs can misread the economic effects of the ports unless appropriately reflecting the intensification of the functional integration and the spatial enlargement of the port-related activities. This interpretation can be supported by the result that the coefficients of *lnTEUp* and *lnTEUr* have much greater changes between the regions with large ports and the regions without large ports than the one of *lnRT* does.

[134] For example, five variables; *lnngd*, *lnSk*, *lnSh*, *lnrd* and *lnRT*, in Busan and Incheon, six variables; *lnngd*, *lnSk*, *lnSh*, *L.lny*, *lnrd* and *lnRT*, in Ulsan, and four variables; *lnngd*, *lnSk*, *lnrd* and *lnRT*, in Jeonnam.

8.3 Contributions

This study introduces the key findings from the sequential analyses with multi-methodology applied. The findings are important not only by themselves but also in the point of suggesting some significant implications for port studies, port impact studies, and port policies. Especially, the implications for port studies and port impact studies derived from the key conclusions are quite helpful not only to understanding of Korean port systems but also to giving a direction for future research in all countries with container-centric logistics.

8.3.1 Key implications for port studies

This study proposes that the GVA per worker in transportation and/or the proportion of transportation in a regional economy is likely to be higher in the regions where a port has a higher proportion of container freight of total cargo volume. In addition, the gaps in the GVA per worker in transportation have been getting bigger over time between the regions with the transport node and the other regions. This study empirically suggests that the port regions with container dedicated facilities have been embedded in the value-added activities by supplying the transport services for the demand in the inland regions.

These results can be generalised to be in line with the recent trend in port studies; so-called, the port regionalization (Notteboom and Rodrigue, 2005, Monios and Wilmsmeier, 2012a) and the port-centric logistics (Pettit and Beresford, 2009, Mangan et al., 2008), etc. The research, focusing the logistics network with container freight-focused, generally stress that the port-related activities are strongly connected with the inland logistics centres located in the adjacent area or even in the inland area spatially disconnected with the port region. This means that the key trend suggested by recent port research happen in practice at the global scale.

8.3.2 Key implications for port impact studies

In the sight of port impact studies, this study suggests that the results of the econometric analysis should be interpreted carefully, based on an understanding of the features of individual regional economies as s part of a national or regional system. This can be backed up by several findings. Firstly, the results of the contextual understanding and the shift-share analysis imply that the 16 regions have quite different industrial structures: especially, in the sight of the status of transportation in the regional economy and the economic contribution of the port in the four major port regions. However, the econometric analysis for the panel data, based on the implicit assumption that panels in individual regions do not have strong heterogeneity (Baltagi, 2008), can suggest some biased results due to the strong heterogeneity. In order to partially avoid or minimize this unconformity, this study introduces sub-groups considering the factors which bring the heterogeneity to the panel data.

This intuition is in line with the previous works by Coppens et al. (2007) and Danielis and Gregori (2013), even though this study applies different methodologies from them. As a result, this study shows that the regression for the whole panel data can underestimate or overestimate the statistical relationship between the port variables and the growth of the regional economy according to the size of the port traffic. It is the point that is different from the previous studies focusing on examining if the ports contribute to the growth of their regional economies (Bottasso et al., 2013, Shan et al., 2014, Park and Seo, 2016)

Secondly, this study suggests several feasible methodologies to be applied in estimating the statistical relationship between the port-related variable and the growth of the regional economy. As considering the characteristics at the level of the descriptive analysis as shown in Table 7-12, a researcher can decide how to apply the econometric analysis; specifically, estimating a single coefficient for the panel data, estimating coefficients by sub-periods or by sub-regions, and estimating a single coefficient for the individual region. This decision making can be implemented generally as considering the intuition from the two-way scatters between the port-related variable and the representative variable of the regional economy (Gujarati and Porter, 1999). Meanwhile, an understanding of the features of individual ports and regional economies is quite helpful to interpret the results of the two-way graph.

Lastly, this study suggests that an explanatory variable should be carefully selected and interpreted: especially, port traffic by RT has the stronger statistical relationship with the growth of the regional economies but container freight contributes the more to the GVA per worker by attracting additional value-added activities as discussed in the previous studies (Notteboom and Rodrigue, 2005, Mangan et al., 2008, Pettit and Beresford, 2009). This contradictory results should be understood to mean that the variable of *lnRT* is more statistically related to the growth of a regional economy (Park and Seo, 2016) but not that the variable of *lnRT* contributes more to the growth of a regional economy. On the other hand, it is inferred to be due to the statistical feature of the econometric analysis mentioned above why the volume of container freight may not represent the relationship with the growth of regional economies as strong as it is in the previous works (Shan et al., 2014, Ferrari et al., 2010). Namely, how much similarly container freights are handled in the major ports is suggested to influence both the magnitude of the coefficient and the significance of the estimators.

8.3.3 Key implications for port policies

This study suggests that the four ports have different characteristics in terms of the spatial distribution of the port users and the range of port-related activities according to the cargo type. Furthermore, these characteristics have a significant influence on the GVA per worker and the proportion of transportation in regional economies. These conclusions give very meaningful implications to the port-related policies of the Korean government, which are focused on the loading and unloading functions. Above all, the port authorities need to analyse the economic effects of the ports at the level of the regional economy rather than the national economy although the Korean port governance has the centralised feature. It is for the recent decades that the economic impact studies in South Korea have conducted in the sight of the regional economy in order to persuade the regional stakeholders of the legitimacy for the port development (Jung, 2014). In this line, this study suggests that the effects of individual ports on the cities are very diverse in the extent and in the magnitude as suggested in the previous studies, even though the port has been developed with the objective of enhancing the efficiency of the national economy (MOMAF, 2001, MLTM, 2011a). This implies that the evaluation of the economic effects needs to be done with more diverse viewpoints applied so that the various stakeholders can share the results and clarify their position with regard to the port-related policies (Dooms et al., 2015). In particular, the current way of depending on the port traffic fundamentally has the severe drawback that it does not properly explain the impact of the port on the regional stakeholders (Ducruet, 2011).

Secondly, in the viewpoint of port governance, the Korean port governance has the unique feature in the point that the port-related policies are generally restrained inside of the port district in terms of the spatial boundary (MOF, 2016a). This is mainly since the competitive relationship has been maintained between the central government that is responsible for most port-related policies and the regional government that is responsible for the spatial planning and other activities in the logistics network (Lee, 2009). However, it is necessary to re-establish the scope of port-related policies while considering the trend that port-related activities have expanded the functional range by connecting and/or integrating with other activities in the logistics network. For example, the effort to strengthen the linkages between the ports and the inland logistics centres are necessary to improve the efficiency of the logistics systems (Notteboom and Rodrigue, 2005). This is in line with the previous studies that argue that the spatial boundary of port policies should be expanded (Notteboom and Rodrigue, 2005, Monios and Wilmsmeier, 2012a).

Lastly, the Korean system of examining the economic effects of the port needs to be evaluated and re-established as a whole. Currently, the study on the economic effects of ports is mainly based on the IO analysis from the viewpoint of the national economy. However, the IO tables produced by the Bank of Korea are not based on individual regional economies but relies on the inter-industrial linkages at the national economy (BOK, 2016). The problem of biased estimation can be not serious in studying the extent to which the port contributes to the national economy. However, it can be quite serious in the case of estimating the economic effects at the regional level by directly applying the inter-industrial linkages estimated at the national economy (Coppens et al., 2007). This is the motivation of introducing the regional IO table which estimates the inter-industrial linkages at the level of the regional economies (Danielis and Gregori, 2013). This implies that the application of the same criteria for the large ports and the small ports can derive the distorted results in the sight of economic efficiency (Shan et al., 2014). As well, this suggests that the application of the econometric analysis also needs to be modified as suggested by this study.

8.4 Limitations and Future Study

Despite the various contributions discussed in the previous section, this study clearly has some limitations and additional research as follows.

From the viewpoint of research methodology, this study applies several methodologies in order to examine both longitudinal changes and the cross-regional differences with regard to the port-related activities. Specifically, this study intended to directly connect the results of the shift-share analysis with the econometric analysis by applying the variables of *CE* and *IM* in the application of the econometric analysis by region. However, this study tried on applying the econometric analysis at the level of transportation but faced the constraint in data acquisition: some existing variables cannot be disaggregated at the level of transportation. Especially, it is not feasible to gather the ratio of income invested in physical capital (*lnSk*) and the ratio of income invested in human capital (*lnSh*) since they are not produced at the industrial level (KOSIS, 2017). If obtaining the data on them, this study could suggest a better understanding for the relationship between the port-related activities and the growth in the GVA per worker of transportation. In addition, it would be feasible to comparatively understand the results of the application of the econometric analysis by region with the variable of *CE* and *IM* applied.

On the other hand, this study suggests that the advantages of the multi-methodologies: the shift-share analysis and the econometric analysis, cannot be ignored although the methodological connection is not concrete. It is expected that meaningful research results can be derived if further studies are conducted. Firstly, the shift-share analysis provides just a little information with respect to the cause and effect of the changes due to the feature that it is fundamentally descriptive. So it will be helpful to analyse further disaggregated data of four sub-sectors in transportation in order to show the changes at the level of individual port-related activities. This analysis can be applied with the disaggregated data at the five-digit level in SIC or by the so-called transport survey.

Secondly, a researcher can obtain useful information on the statistical significance by conducting the econometric analysis at the level of transportation by region if some variables can be disaggregated at the level of transportation. This further analysis will supply the chance to comparatively understand the relationship between the shift-share analysis and the econometric analysis and between the port-related activities and transportation in a regional economy. Especially, this analysis is expected to supply some statistical information whether the growth of transportation and/or regional economies is influenced from the intensification of the functional integration and the spatial enlargement of the port-related activities or not. Meanwhile, this study would like to recommend that the future research should consider and/or reflect some significant implications. First of all, the contextual understanding of the features should support to implement the econometric analysis and interpret the results at the level of country, region and individual port by applying various methodologies. In particular, understanding of structural changes in regional transportation is substantially helpful to decide what approach to apply and how to implement as discussed chapter 7. In addition, the econometric analysis should be implemented in the line that port-related activities are industrial sectors in a regional economy. Port-related activities which can be classified differently by port according to cargo type composition, the spatial boundary for service, and the degree of the connectivity in the global supply chain. As discussed in previous, this significantly influence the sectoral structure and the spatial service boundary of its regional transportation. In this line, the econometric analysis should be implemented as reflecting some further variables; for example, the ratio of container freight out of the total port traffics and dummy variable related to the spatial scope in service. Especially, the data of physical capital and human capital at the level of transportation provably make the econometric analysis more efficient.

Lastly, this study analyses the four major ports in South Korea, but the approach may be useful to study the port system in the countries or states in which several ports are located and that have a similar port governance as the one in South Korea. Especially, this approach will be helpful in that the centralised port authority usually makes influential decisions for individual ports and needs to communicate with the regional stakeholders.

APPENDICES

Appendix 1 Port Systems in South Korea

A.1.1 Port development

According to KPHA (2011), all Korean ports had been located at riversides or coastal area inside of bay which was surrounded by a kind of natural breakwaters like islands. It is not until Busanpo and Jemulpo opened at the end of 19th century that the port mainly aimed to transport international freight. In addition, it was in 1902, when the lighthouse office in Incheon custom was established to construct seaways that the government began to control and be directly related to developing trade ports. Through 35 years of Japanese colonial rule, the facilities in several international ports[135] were built in order to import military supplies from and export cereal crops to Japan; especially, in the sight of loading capability, almost half of the total port facilities were concentrated on the Port of Busan which is nearest to Japan. In the 1950s, port loading capability in Korea crashed down due to political instability after the liberation of Korea in 1945 and the Korean War in 1950. Even undestroyed ports experienced a significant drop in the loading capability because port facilities had not been properly maintained; seaways not to be dredged. Meanwhile, the efforts to recover the loading capability and improve port facilities had been made since the late 1950s.

Since the 1960s, as mentioned in the previous section, the national economy has developed remarkably with substantial increases in exports, which in turn has brought about a rapid increase in the volume of exports and imports (Song and Lee, 2017). As a part of the economic development plan, port development led by the central government proceeded in earnest under 'five-year plan for economic development'. The history of the port development in Korea can be classified into four phases focused on the top priority of the port development strategy as shown in Table A-1. As the first phase, in the 1960s, Korean government put the top priority in port development on reinforcing existing facilities in trade ports and constructing a new port and new facilities in existing ports in order to support companies in industrial districts under construction. The example of the former is the Port of Busan and the Port of Incheon, and the one of the latter is the Port of Ulsan and the Port of Pohang. Generally speaking, port development in this phase was limited to several ports under the principle of selection and concentration due to the lack of government's budget.

As the second phase, during the 1970s and the early 1980s, the priority of port development policy was set newly according to the five-year plans for economic development.[136] Constructing new industrial ports for shipbuilding and oil refining has been implemented at a nationwide. For an instant,

[135] What had opened before Japanese annexation of Korea in 1910 were 10 ports: Port of Busan in 1876, Port of Wonsan in 1880, Port of Incheon in 1883, Port of Mokpo and Port of Jinnampo in 1897, Port of Gunsan and Port of Seongjinpo in 1899, Port of Yongampo in 1906, Port of Cheongjin in 1908, and Port of Sinuiju in 1910.
[136] The objective is to promote heavy industries such as ironworks, shipbuilding, and oil refining.

Table A-1 Historical brief review of port development policies in South Korea

Phases	Years	Top priority	Representative projects	Project effects
Phase 1	1962-1971	➢ Reinforcing existing facilities in trade ports ➢ Constructing new facilities in ports to support industrial districts	o Port of Busan: constructing lighter's wharf, dredging o Port of Incheon: constructing the 2nd wharf o Port of Ulsan: the 2nd wharf, the 4th wharf o Port of Pohang: starting constructing the port in 1968	o Investment: 38 billion KRW o Accommodating capacity: 63 berths in 1962, 81 berths in 1971
Phase 2	1972-1986	➢ Expanding new facilities in trade ports ➢ Constructing new industrial ports	o Port of Busan: constructing the 5th wharf, the 6th wharf and the 7th wharf, reinforcing existing four wharves, constructing water breakers in Gamcheon port o Port of Incheon: constructing lock gate, the 3rd wharf and the 4th wharf o Port of Ulsan: constructing the 3rd wharf and the 5th wharf o Port of Gunsan: constructing port facilities along coastal area (Outer Port of Gunsan) o Other trade ports: constructing the 3rd wharf in Port of Masan and three quay walls in Port of Jeju o Industrial Ports: Port of Samil, Port of Okpo, Port of Mipo, Port of Changwon, Port of Onsan, Port of Bukpyeong, Port of Gwangyang (the 2nd steel plant for POSCO).	o Investment: 1,176 billion KRW o Accommodating capacity: 81 berths in 1972, 199 berths in 1986
Phase 3	1987-1996	➢ Constructing container dedicated facilities in trade ports ➢ Expanding cargo dedicated facilities in industrial ports	o Port of Busan: constructing water breakers and container dedicated terminals (12 berths) outside North port, constructing cargo loading facilities in Gamcheon port o Port of Incheon: constructing the 5th wharf and the 6th wharf in Inner Harbour, constructing car-ferry terminal and coastal ferry terminal outside of Inner Harbour o Port of Gwangyang: constructing the 1st container dedicated terminal (four berths) o Other trade ports: constructing Port of Pyeongtaek, reinforcing Port of Gunsan and Port of Mokpo o Industrial Ports: Port of Yeocheon, Port of Pyeongtaek,	o Investment: 2,537 billion KRW o Accommodating capacity: 199 berths in 1987, 520 berths in 1996
Phase 4	1997-2015	➢ Constructing new ports in existing ports	o Established 'New port construction promotion act' in 1996 o Designated 'six ports' in 1997, 'two ports' in 1999, 'one port' in 2007 o New Ports: New port in Port of Busan, Port of Gwangyang, Port of Pyeongtaek, New port in Port of Boryeong, New outer port in Port of Mokpo, Yeongilman port in Port of Pohang, North port in Port of Incheon, New port in Port of Ulsan, New port in Port of Incheon	o Investment: 23,060 billion KRW o Accommodating capacity: 520 berths in 1997, 931 berths in 2015

Source: compiled by the author from KPHA (2011), MLTM (2012b), MOF (2016a), (MOF, 2016b).

the Port of Gwangyang began to be developed in order to support the 2nd plant of Pohang Steel Corporation (POSCO). In addition, constructing port facilities in trade ports; especially, wharves and/or piers have been constructed through extending existing wharves and/or expanding them to a nearby area. For example, three wharves with several berths have been constructed in the Port of Busan, the Port of Incheon and the Port of Masan at the same time. Generally speaking, this phase is the period that port development plan was focused on increasing the number of the berth and supplying enlarged wharves to meet the explosively increasing loading and unloading demands.

As the third phase, during the late 1980s and the early 1990s, maintaining the consistency of the plan for economic development and reflecting the changes in the shipping industry, port development put the priority on constructing container dedicated facilities in trade ports and expanding dedicated facilities by cargo types. In the Port of Busan, three container dedicated wharves which are consisted of four or five berths were constructed at the outside of the inner breakwaters, as building new breakwaters. In the Port of Gwangyang, the first container terminal which had four births was constructed. As an industrial port, the Port of Yeocheon and the Port of Pyeongtaek has been constructed in order to handle the liquid cargo which was imported to coastal industrial districts. Applied by J. Bird's model, this phase may be simple linear quayage of the fifth era and specialized quayage of the sixth era.

As the fourth phase, since the middle 1990s, the priority has been put on constructing new ports in order to accommodate the ever-increasing size of ships for cargo types, including container ship and tanker, since the 1980s. What is representatively different from the third phase is that port facilities are constructed generally on a large scale at the place which is far away from the existing port even though new ports are managed in the same frame of the existing ports.[137] This phase can be understood that the specialized quayage is progressed on a large scale beyond the boundary of the existing port.

In this sub-section, this study reviews briefly what the priority of port development policy has been and what projects have been implemented. So, which phase each port is in is reviewed in the next chapter. In following the above review, this research overviews port facilities and port traffic in 2015.

A.1.2 Port Governance

As discussed in the previous section, Korea has experienced huge and drastic changes both in political systems and in the national economy. Korean ports have been in the front line of the changes due to the characteristics that ports are located in each region but most of them are controlled by the central government. As mentioned by Song and Lee (2006), in the aspect of port governance, Korean

[137] For example, the New Port in the Port of Busan which has 24 container dedicated berths is 34km by straight line distance far away from the North Port which is the centre of the Port of Busan.

ports have experienced never-ending changes since the 1960s. In the 1960s, the government was an all-around player which did everything including port planning, development, management, and even operation. However, the authority and the responsibility have gradually been devolved to various entities to meet the demands of various stakeholders. This sub-section aims to discuss the evolution of port governance largely focused on the port-related actors including terminal operators.

A.2.2.1 Administrative system

An administration which is responsible for port-related and maritime policy has changed so rapidly and repeatedly even though it has been about 70 years since the Korean government had established in 1948, as shown in Table A-2. It is clear that the history of the port-related administrative system in the central government may be the process which port-related tasks were tied and untied. With regard to port management and port development, the history can be divided into two periods; before and after 1976 when port management and port development are kept connected to the same entity. Considering the objectives of this study, this study overview the history with administrative systems focused after 1976. In 1976, the Korea Maritime and Port Administration (KMPA) established as an independent organization under the Ministry of Transport (MOT) by uniting departments under various ministries which were responsible for port-related policies; especially, port development controlled by the Ministry of Construction (MOC) and port management implemented by the Ministry of Transport (MOT). This united organization was to stimulate development in both the shipping industry and port-related industry and had stood up until 1996 when the Ministry of Maritime and Fisheries Affairs (MOMAF) was established (KPHA, 2011).

Table A-2 Administrative system in the central government

<table>
<tr><th>Year</th><th>1948</th><th>1955</th><th>1962</th><th>1976</th><th>1996</th><th>2008</th><th>2013</th></tr>
<tr><td>Maritime Affairs</td><td rowspan="2">MOT</td><td rowspan="4">MCI
⋮
MAA</td><td rowspan="2">MOT</td><td rowspan="3">MOT
⋮
KMPA</td><td rowspan="4">MOMAF</td><td rowspan="3">MLTM</td><td rowspan="4">MOF</td></tr>
<tr><td>Port Management</td></tr>
<tr><td>Port Development</td><td>MHA</td><td>MOC</td></tr>
<tr><td>Fishing Port</td><td>MCI</td><td>MAF</td><td>MAF</td><td>MFAFF</td></tr>
</table>

Note: MOT: Ministry of Transport, MHA: Ministry of Home Affairs, MCI: Ministry of Commerce and Industry, MAA: Maritime Affairs Administration, MOC: Ministry of Construction, MAF: Ministry of Agriculture and Forestry, KMPA: Korean Maritime and Port Administration, MOMAF: Ministry of Maritime and Fisheries Affairs, MLTM: Ministry of Land, Transport and Maritime Affairs, MFAFF: Ministry of Food, Agriculture, Forestry and Fisheries, MOF: Ministry of Oceans and Fisheries.
Source: compiled and drawn from KPHA (2011).

In 1996, the MOMAF was established with 7 Bureaus in-house through uniting KMPA and Korea Fisheries Administration (KFA) and transferring marine–related tasks from other ministries. Even though the MOMAF was established in order to promote marine industry and strengthen the capability in coastal management and marine territory rather than port-related industries, it brought huge changes in port-related industries as well. As the status of the entity in the central government got higher[138] and the entity became an independent ministry from the MOCT, various port-related policies could be planned and implemented much more efficiently and effectively than before: for example, increased the budget for port development and shortened time period of enacting laws.

However, in 2008 after the new President in the opposition party was elected and the new government was inaugurated, the MOMAF became separated and emerged into the Ministry of Land, Transport and Maritime Affairs (MLTM) and the Ministry of Food, Agriculture, Forestry and Fisheries (MFAFF). Again, due to a presidential election pledge, the Ministry of Oceans and Fisheries (MOF) was re-established with the entity, which consists of three offices and three bureau, almost same with the former MOMAF in 2013.

Through the brief overview, the key trend of the administrative system can be said that port-related and sea-based activities are integrated into a united entity in order to promote co-operation among relative areas and implement the capability to execute policies. On the contrary, the Korea government has changed the authority and the responsibilities of the central government with regard to port development and management through devolving various actors. This took place as a part of both structural changes in the political system and ever-lasting revolution in the national economy. These changes are overviewed briefly in the frame of the devolution in the next sub-section.

A.2.2.2 Devolution of port-related authority

Since the 1980s, port governance-related issues have been the top priority of port-related policies in many governments all over the world[139] (Brooks and Pallis, 2012). The key goal of the changes in port governance which was intended by the governments must be increasing the management efficiency through devolving port-related authority and responsibility of the government to full or partial private bodies both at a regional level and at a national level. These worldwide changes in port governance have taken place extensively in Korea.

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[138] Ministry is higher than administration in the hierarchy of Korean government structures. But the Mister has several authorities based on the laws; attending cabinet meeting which the President presides, proposing the amendment of existing laws and the draft of enacting law to the National Assembly, and making and managing enforcement ordinances of laws, etc.

[139] They argued that new global economic system of production and distribution indirectly resulted in the changes in port governance mediated by the changes of international cargo transportation and the role of ports in the global transportation systems.

According to Rodal and Mulder (1993) cited in Brooks and Cullinane (2006b, p. 5), devolution is defined as 'the transfer of function or responsibility for the delivery of programs and services from federal government to another entity, which may be another order of government or non-governmental organization, community group, client association, business or industry.' Based on this understanding, Brooks and Cullinane (2006b) suggest four types of devolution[140], which are broader than Rodal and Mulder (1993)'s control-consultation-partnership continuum and Brooks et al. (2000)'s control-consultation-partnership-privatization continuum.

Even though they broaden the scope of devolution, their classification has limitations in two points. One is that privatization is the exceptional type of the devolution which is applied only in the UK (Brooks, 2004). The other is that it focuses on the existing port facilities because their case studies surveyed just how existing port facilities are managed. As a result, it is not clear which category the port facilities constructed and managed by a public-private partnership may be sorted in. In addition, as overviewed in the previous section, the hierarchy of port development and management is much complicated in Korea than one in Europe.

For this reason, this study overview the devolution both at a terminal level and at a port level. And then, this study clarifies which type of devolution has been implemented in port management.

A.2.2.2.1 Devolution at a terminal level

Ports have been developed and managed mainly under the principle that port facilities as a social infrastructure must be controlled by the central government; especially, the ownership of the dockland raised through port construction is basically attributed to the nation. It is the government policy that has been consistently maintained more than half-century after the establishment of the Korean government in 1948. However, through the 1960s when the demand for port facilities grew rapidly over time, the participation of private bodies in the port development and terminal operation was gradually expanding through several methods.

[140] They compare and classify four types of devolution by nine characteristics; changed government objectives, changed organizational structure, establishment of a legal entity, control of operations and management, ownership of existing capital assets, ownership of new capital assets, responsibility for risk, right to borrow money, and ability to sell the assets. The key characteristics are what entity takes the right and responsibility, and who owns the existing assets.

- Decentralization is that regional or local government takes the right and responsibility whether it owns the existing assets or not.
- Commercialization is that a new legal entity, which doesn't have share capital, takes right and responsibility of port management without ownership of existing capital assets transferred.
- Corporatization is that a new legal entity, whose share capital may be owned in part or in full by government, takes right and responsibility of port management regardless of ownership of existing capital assets.
- Privatization is that a private corporate whether is established or not takes right and responsibility of port management with ownership of all capital assets transferred or owned.

First of all, private bodies were permitted to construct and own port facilities including even wharf and quay wall based on non-governmental port construction[141] in the Harbour Act (MOF, 2016a). As mentioned above, the Korean government has the consistent policy that the wharf and the quay wall should be owned by the central government so it is the quite exceptional case that private bodies had the ownership of the wharf and the quay. In reality, port facilities in several industrial ports which were constructed in the 1970s and the 1980s were built with this method applied and owned by the private corporation such as POSCO and Hyundai Heavy Industry. On the other hand, a number of port facilities in trade ports were constructed with this method applied after the 1980s[142] but the ownership of the wharf was attributed to the central government. This method contributed hugely to the explosive increase of port facilities during the 1990s and the 2000s (MOF, 2016a).

Secondly, the participation of the private sector in port operation in Korean trade ports is based on the selection of the operator of the Jasungdae Wharf in 1974 (Jung and Sung, 2003).[143] However, Busan Container Terminal Operation Company (BCTOC), which was the operator of the Jasungdae Wharf, was established in 1974 and operated as a public corporation continuously (KPHA, 2011). Since then, as the waiting of ships had been prolonged severely through the 1980s due to the lack of port facilities, the Korean government promoted the construction of port facilities and the improvement of operation efficiency. On the one hand, the Korean Container Terminal Authority (KCTA) was established in 1990 in order to do the former. On the other hand, the participation of the private in wharf operation was promoted since 1991 to solve the latter. In addition, this policy direction was applied in various ways: for example, the privatization of BCTOC,[144] the commission to the private sector with regard to the operation of the Sinsundae Wharf in 1991 and the introduction of Public Private Partnership (PPP) in port development projects in 1995 (Jung and Sung, 2003).

Thirdly, the Korean government enacted the Korean Container Terminal Authority Act and established the Korean Container Terminal Authority (KCTA) in 1990 in order to adapt the changes in and around the global shipping industry; especially, the rapid containerization of international cargo and the enlargement of container dedicated ships. And then, the Korean government consigned

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[141] If anybody who is not a government entity would like to construct and/or repair port facilities, he should get the permission from the governmental body who is responsible of building and managing port facilities. The private body has the right to use the port facility free of charge until port facility fee is equal to the amount invested.

[142] As the debates related to the ownership of the wharf and quay wall were raised, the government revised the rules that the ownership of port facilities could be decided according to the facility.

[143] The project, which is the first stage of port development projects in the Port of Busan, was implemented with the debt from International Bank for Reconstruction and Development (IBRD), which requested the condition that the terminal should be operated by the private terminal operating company.

[144] The system of Terminal Operating Corporation (TOC), which was originated in the Port of Busan, got expanded to 8 ports in Korea in 1997 and has been gradually extended to the private sector through 2000s. At the moment, the wharf operation is fully undertaken by the private bodies.

constructing and managing container dedicated terminals (KPHA, 2011)[145]. As a result, the KCTA has completed the development of 20 container-dedicated berths[146] and has managed, but not operated, 12 terminals in five ports, including the Port of Busan and the Port of Gwangyang (MOF, 2016a). However, as discussed below, as four Port Authorities were established since 2004 in order to devolve the responsibility of the central government at a port level, the KCTA has handed over the container terminals to the PAs step by step. Finally, the KCTA was abolished to hand over all facilities in the Port of Gwangyang in 2011 when the Yeosu-Gwangyang Port Authority was established (MOF, 2016a).

Lastly, the Korean government established the 'Promotion of Private Capital into Social Overhead Capital Investment Act[147]' in 1994 in order to promote the investment of private sectors into social infrastructures and manage the projects systematically. Since 1995, PPP became one of three methods which private bodies could take part in the port development. Until 2015, 16 projects in five ports, which consisted of 7,240m quay wall with 48 berths and 1,200m lighter wharf with 5.32 trillion KRW[148] invested, have been implemented (MOF, 2016a).

A.2.2.2.2 Devolution at a port level

As discussed above, the Korean government has faced increasing pressures from decentralizing port-related authorities and responsibilities since the mid-1990s, despite the various attempts at expanding the participation of private bodies at the terminal level. As a result, the government dealt with the intensifying demands of decentralization in port development and management in two directions (Song and Lee, 2017, Lee, 2009). One is, in the case of major ports, that the government established the PA in each port and commissioned the authority and the responsibility for port-related activities except for the roles as a regulator including safety- and seaman- related responsibility. The other is, in the case of small trade ports, that the government commissioned the authority and the responsibility to the municipal governments.

On the one hand, as the devolution of port-related authority and responsibility to new legal entity, Korean government enacted the Port Authority Act (PA Act) in 2003 and established the PAs[149]: the

[145] The ownership of container terminals which the KCTA constructed were attributed to the government as soon as constructing of the facilities were completed and all rights except for the ownership were mandated to the KCTA from the government free of change. The KCTA could cover the investment to the container terminals with the rental fee from terminal operating corporates.
[146] The container-dedicated wharves are Sinsundae Wharf (5 berths), Gamman Wharf (4 berths), and New Gamman Wharf (3 berths) in the Port of Busan and the phase 1 (4 berths) and the phase 2 (4 berths) of container terminal construction projects in the Port of Gwangyang.
[147] The English name of the act was changed to the Act on Private Participation in Infrastructure in 1999 and the Act on Public Private Partnerships in Infrastructure in 2005.
[148] Applying the currency (1 GBP = 1,447 KRW on 09 January 2018), it values 3.67 billion GBP.
[149] The PAs are a new legal entity in the sector which is so-called a public and private combined entity. This is benchmarked from the corporation model of Singapore that PSA Corporation was established as a new legal

Busan Port Authority (BPA) in 2004, the Incheon Port Authority (IPA) in 2005, the Ulsan Port Authority (UPA) in 2007, and the Yeosu-Gwangyang Port Authority (YGPA) in 2011. The central government responded to the increasing requests of establishing the PA, which was raised in the line of the decentralization by regional governments and political circles, as the issue of how to increase the management efficiency under the control of the central government (Lee and Lam, 2017). As a result, the PAs are established as a new legal entity which is fully owned by the central government as aiming to embody 'private spirit' to port management and to increase the management efficiency of a new entity[150] (Song and Lee, 2017). The PAs manage most of the port facilities in the port district and some specific facilities outside of the port district which had been owned by the government. However, some facilities such as breakwaters and marine transport-related facilities are not included in order to alleviate the financial burden of the PAs.

On the other hand, as so-called decentralization, the Korean government (MLTM) revised the Port Act in 2009 in order to devolve the port-related responsibility of the central government to regional governments. As discussed in the sub-section of port classifications, Korean ports which are controlled under the Port Act are classified into trade ports and coastal ports. Before the revision in 2009, 31 trade ports had been developed and managed by the central government and 29 coastal ports had been done by the regional governments. As mentioned by Lee (2009), the regional governments have been under increasing pressure to influence the port-related policies due to the trend that trade ports have been getting closely related to the life of regional stakeholders and their political demands to influence port-related policies. As a result, accommodating the demands from various bodies, the Korean government devolved the authority and the responsibility in terms of port development and port management of 17 trade ports[151]. On the other hand, 11 coastal ports, which are important in the sight of the national defence and the marine territory, entered into the control of the central government.

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entity in order to succeed Port of Singapore Authority. The PAs in Korea are in full responsible for port operations and development both port district and its back-up areas; for example, so-called Distriparks and transport supporting facilities.

[150] The PAs is managed with the independent accounting applied but controlled by the central government with regard to key decision making like the sale of port-related assets. A capital contribution was respectively made to BPA, IPA, UPA and YGPA by the central government by 2 trillion KRW, 5 trillion KRW, 0.15 trillion KRW and 1.2 trillion KRW when they were established.

[151] The Port Act defines the criteria of port classifications that the minister of MOF can decide the classification of a port in order to manage and operate trade port systematically and efficiently as considering import and export volume, development plan and regional balanced development.

- National trade port: a port which has a significant relation with the benefit of the country through handling nationwide trading cargos and supporting main industry as a base of national and international maritime and maritime transportation network.
- Municipal trade port: a port which is mainly used to handle local trade cargo as a base of local land and maritime transportation network.

Appendix 2 Contextual Understanding of the Four Major Ports

A.2.1 Port of Busan

A.2.1.1 Port development

It is not until the 1970s that the Port of Busan began to be developed as accommodating the changes in the shipping industry such as the enlargement of ships, the containerization and the introduction of specialized ships by the cargo type (KMPA, 1991).[152] Figure A-1 shows both where major facilities have been developed and when they were opened. From the figure, the process of the port development can intuitively be classified into four stages[153].

First of all, as the first phase, the Port of Busan had been set on the coastal area nearby Jungang-dong, which was the CBD in Busan by the 1990s, during the first half of the 20th century. Port facilities constructed during this period include the Pier 1, Pier 2, the Central Pier, Pier 3, and Pier 4 which are denoted by number 1 in the blue circle. These facilities had been designed as reflecting the characteristics of the shipping industry in the early 20th century so they were shaped just like the prominence and depression (KPHA, 2011). In addition, they were periodically reinforced in order to accommodate the enlarged ships and the container cargos since the 1960s (MOF, 2016b).

The second phase is the period that the port facilities were developed and operated mainly in the inner area of North Port until the 1970s and early 1980s. In this period, it started to be developed as a wharf with a linear quay and huge space for storing cargos before loading and after unloading (KMPA, 1991). On the other hand, the port development policy focused on the increase of the capability to handle general cargo but not specified the types of the freight (KPHA, 2011).[154] So, this phase is classified as the period of expansion. The facilities developed at this period are Pier 5, Pier 6, Pier 7 and Pier 8.

As the third phase, from the late 1980s to the early 2000s, the Port of Busan was extended to the outer area of North Port, Gamcheon Port and Dadaepo Port. It is the period that the demand for port

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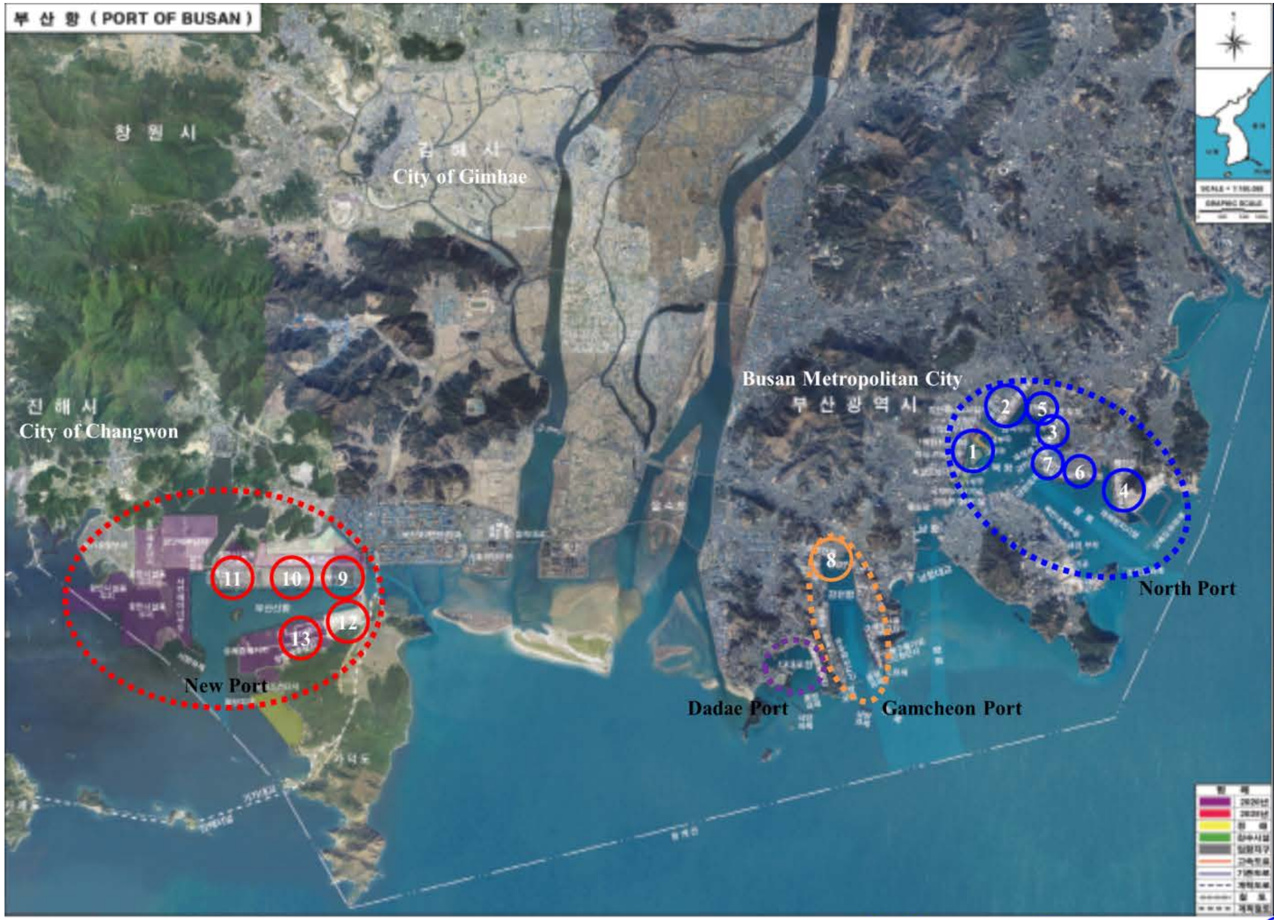
[152] In the 1960s, the maintenance projects which aimed to keep the function of port facilities were intermittently implemented in the Port of Busan.

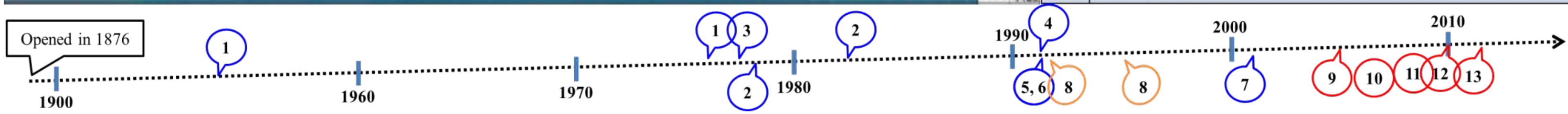
[153] Bird (1963) divided the procedure of port development into six phases: the primitive port, marginal quay extension, marginal quay elaboration, dock elaboration, simple lineal quayage, specialised quayage. On the other hand, Notteboom (2005) modified it into three phases of setting, expansion and specialization and added regionalization as the fourth phases. However, this research borrows the classification of Notteboom (2005) but not the fourth phase of regionalization. It is due to the difference of the sight that the regionalization was defined in the sight of the relationship between port activities and land transport activities instead of the morphological sight which is applied to three phases.

[154] The 5th wharf and the 6th wharf were integrated into Jasungdae container terminal when the 6th wharf was opened. Meanwhile, the 7th wharf and the 8th wharf were constructed to handle various bulk cargo except for cereal crops and raw materials (KPHA, 2011).

Figure A-1 Map and a brief history of the port development of the Port of Busan



No	Contents
1	**Pier 1, 2, 3, 4** and **Central Pier (437m, 924m, 1,145m, 1,311m, 646m)**: constructed from 1911 to 1944 and renovated as the 1st phase of the port development project (1974-1978) and the 2nd phase (1978-1983)
2	**Jasungdae Wharf (1,447m)**: **Pier 5** was constructed as the 1st phase, **Pier 6** was done as the 2nd phase, operated by a single operator from 1974.
3	**Pier 7, 8 (674m, 1,001m)**: constructed as the 1st phase from 1974 , operated in 1978
4	**Sinseondae Wharf (1,500m)**: constructed as the 3rd phase from 1985, operated in 1991
5	**Uam Wharf (500m)**: constructed as the 4th phase from 1985, operated in 1991
6	**Gamman Wharf (1,400m)**: constructed as the 4th phase from 1985, begin to operate in 1991
7	**Singamman Wharf (826m)** : constructed from 1985, operated in 2002
8	**Central Pier, Pier 5 and 6 (1,100m, 800m, 590m)**: constructed from 1979, operated gradually from 1991
9	**The 1st Wharf (1,200m)**: constructed as the 1st phase of the New Port development project from 1995, operated in 2006
10	**The 2nd Wharf (2,000m)**: constructed as the 1st phase from 1995, operated in 2007
11	**The 3rd Wharf (1,100m)**: constructed as the 2nd phase from 1995, operated in 2009
12	**The 4th wharf (1,150m)**: constructed as the 2-2 phase from 2000, operated in 2010
13	**The 5th Wharf (1,400m)**: constructed as the 2-3 phase from 2000, operated in 2011



Source: compiled by author from KPHA (2011), MLTM (2012a), MLTM (2011a), MOF (2016b), MOF (2016a), and BPA website, etc.

facilities exceeded the capability of the existing facilities and the potential demand also would be quite bigger the capacity of the facilities which were supposed to be opened in North Port. For this reason, port authorities had huge interests in increasing the efficiency with regard to cargo handling (KMPA, 1991). For instance, it was the cause of the inefficiency that various types of freight such as container cargos and general cargos were handled in the same Pier and Wharf; especially, container cargos increased explosively since the 1980s. So, the port development policy had focused both on the expansion of port facilities and the specialization of them. The port facilities constructed during this period are not much different from the ones in the second phase in terms of the designed layout, but relatively larger in size than the existing facilities (KPHA, 2011). Typical facilities are the container-dedicated wharfs such as the Sinsundae wharf, the Gamman wharf, and the Singamman wharf located in the outer area of North Port, and the Central Pier, Pier 5 and Pier 6 in Gamcheon Port, which were constructed to handle bulk cargos.

Lastly, as the fourth phase, the Port of Busan has experienced the prominent expansion in size one more time since the second half of the 2000s. The Port of Busan had been stuck in severe problems such as the lack of port facilities, the spatial limitation of port districts, and the heavy congestions on nearby roads since the 1990s (MOMAF, 2001). In order to solve the limitations, the government had planned to construct New Port[155] so that several projects for the New Port construction have gradually launched since 1996. Since the 1st Wharf, which is operated by Port Authority of Singapore (PSA), opened in 2006, four more Wharves have opened gradually in 2007, 2009, 2010 and 2012.[156] The facilities constructed in this period are characterized by a linear quay and the double-sized width of container yard (CY), compared to existing container wharves in North Port. In addition, New Port has quite a huge amount of distribution centres which began to be operated in 2008 (MLTM, 2012a).

A.2.1.2 Interaction with the city

In the sight of the interaction with the city, the port has been in the close but rapidly changed relationship with the city for the last several decades; especially, as a strong engine of both economic growth and urban expansion. In this part, the interaction with the city is briefly overviewed following the development phases of the port above.

In 1970 when the port had settled down, Busan was already a metropolitan city[157] with a population of 1.84 million and governed the jurisdiction of 373 km^2. The city hall of Busan was located in the

[155] New Port, which is located in the jurisdiction border between Busan and Changwon, is 35km away from North Port by the straight line distance.
[156] As of the end of 2015, New Port consist of five container dedicated terminals and one multi-purpose wharf. The length of five wharfs is 1,200m, 2,000m, 1,100m, 1,150m, and 1,400m. The width of on dock CY is 600m on average.
[157] The government of Busan was independent from the one of Gyeongnam in 1963.

coastal area in Jungang-dong nearby the Pier 1. In the 1970s, the port had suffered a lack of facilities for storing international cargos before loaded to and after unloaded from ships, even though the central government reinforced port facilities in Pier 1 to Pier 4. In addition, this challenge was getting severe rapidly, even though the government expanded facilities for loading and unloading international cargos since the early 1970s (KMPA, 1991). As a result, Busan had grown rapidly in the aspects of the regional economy and the urbanized area due to the explosive increase of port traffics and the establishment of numerous private depots in the outskirts of the city (Yang and Lee, 1991). This trend continued by the mid-1990s, even though the government implemented various policies; developing wharves with the large-scale on-dock CY, supplying the space for depots at the large-scale nearby wharves, so-called off-dock container yard (henceforth ODCY), and even distributing bulk cargos to Gamcheon Port (MOMAF, 2001). During the 1980s, Busan had experienced the large-scale influx of the population so that the city grew rapidly into a city of 3.79 million in 1990. Generally speaking, the port had attracted or contributed to the growth both of the population and of the expansion of Busan until the early 1990s.

However, passing through the mid-1990s, the city had been in various severe problems such as the lack of the urbanized space, including housing and commercial districts, and the heavy congestions due to the rapid and continuous increase for the short time period. As a result, since the late 1990s, the city had gradually not only changed the function of the space used for ODCY and urbanized the areas but also constructed several main routes of the road with the financial supporting at the large scale from the central government (Yeo and Koo, 1997, MOMAF, 2001). In addition, the city had requested the central government for developing the complex of ODCY at the outside of Busan since the late 1980s and Yangsan Inland Container Depot (ICD) became opened in 2000 (Lee et al., 2015).[158] Finally, the areas used for freight stations had been redeveloped to the housing district and the commercial district through the 1990s to the early 2000s; for example, new towns in Suyoung and the Centum City in Haeundae. In the same line, the confliction between the port and the city were getting severe in the area of the original CBD, where the first generation of port facilities was located and finally reached to formally introduce the redevelopment project in the area between Pier 1 and Pier 4 in 2007 (MLTM, 2011a). In addition, the conflicts seem to be the issue in every day and in everywhere as the interface between the port and the city were getting broad while port facilities spread over outskirts of the city along the coastal line (MLTM, 2011b).

On the other hand, as New Port began to be developed in 1996, the interaction with the city has verified by the sub-divisions since the late 1990s; for instance, mainly in the conflicting relationship

[158] Yangsan ICD is located in the City of Yangsan in Gyeongnam Province where is nearby the northwest area of Busan. The construction project was launched in 1994 at the area of 721 thousand m^2 with the investment of 158 billion KRW by the government and the private companies.

in North Port and mainly in the cooperating relationship in New Port. While the construction projects of New Port was implemented from 1996 to 2006, the area nearby the port and 10-kilometre area in radius was almost the vast field, which was managed as a green belt zone, except for the Noksan National Industrial Complex (MOMAF, 2001).[159] However, the city tried to release the restriction to the vast area in green belt zone and finally succeed in doing it to develop the area by the reason that huge amount of space needs to be developed for supporting New Port in 2009 (Song, 2013). In fact, the city has attracted a considerable amount of investment from both domestic and foreign corporations focusing the business with the geographical strength based on New Port (Song, 2012). As a result, the city has been expanding the urbanized area to the hinterland of New Port by promoting large-scale industrial complexes and urban development projects in the 2010s. Today, the port and the city maintain a mutually dependent relationship in North Port and New Port

A.2.1.3 Status of the port

In this sub-section, this research examines what the status of the port in the port systems in Korea is both through examining the changes of port facilities, centred on quay wall, and port usage since the 1970s. Especially, the role of the port can be examined by looking at regional compositions of the freight.

As shown in Table A-3, it is clear that the Port of Busan has grown remarkably for 45 studied years in terms of port facilities and port utilization. In terms of port facilities, as of 1971, the total quay wall, which was 5,273m long, could accommodate 33 ships by the designed criteria, so a berth was 163m long on average. And then, the port facilities have increased prominently every ten years, as the port development has progressed in earnest. As a result, the total quay wall, which is 29,285m long, can accommodate 123 ships at the same time by the designed criteria.

What is interesting is that the number of berths has increased significantly by 1990 but the length of the quay has increased significantly since 1990. The average length of the quay walls had been less than 170m by 1990, but the average length of the quay walls has rapidly increased after the 1990s and reached 240m in 2015. This can be understood as the result of a large increase in the size of the wharf facility due to the opening of container dedicated wharves in both North Port and New Port.

In the sight of port utilization, the Port of Busan has experienced the skyrocketing increase in terms of ship callings and annual freight handled. On the one hand, the number of ship callings has increased from 40,290 vessels in 1970 to 98,087 vessels in 2015. The growth rate seems to be quite small compared to one of the port facilities. However, as looking at the total weight of vessels, the growth rate is much bigger. In other words, the weight, which is 1,248 million tonnes in 2015, has

[159] The national industrial complex, which is located around Myeongji-dond in Busan and Yongwong-dong in Changwon, began to be developed by the area of 7 km^2 since 1999.

increased by almost several times compared to one in 1990. As a result, the average weight per ship in 2015 is almost twice that of 1990.

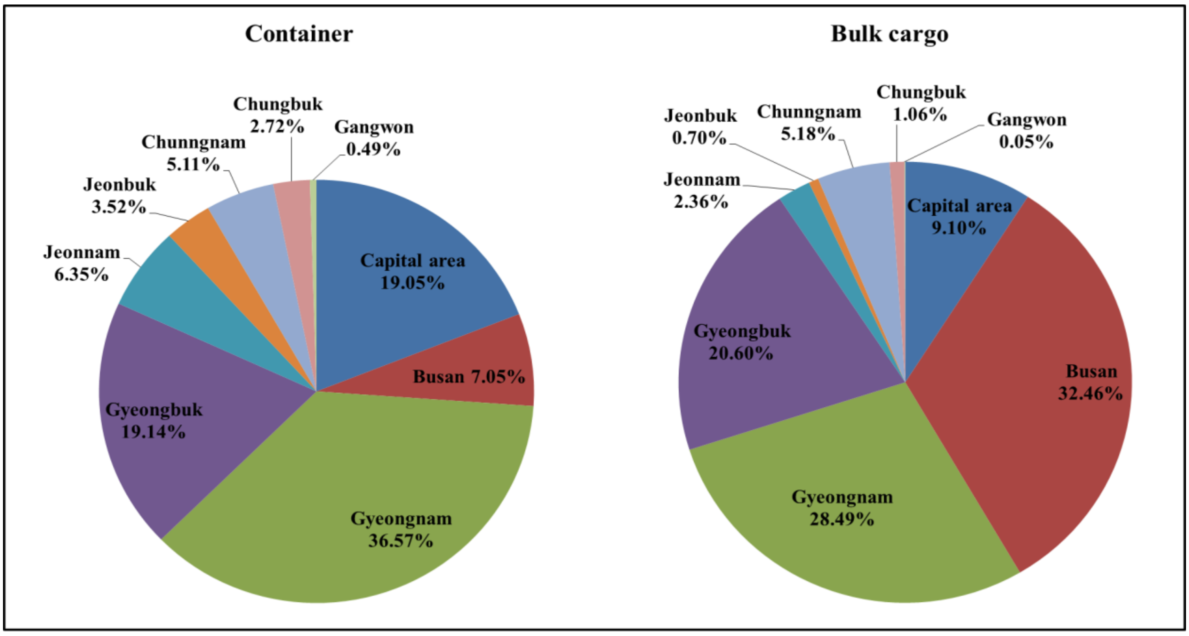
On the other hand, the amount of annually handled freight is 359 million tonnes in 2015, which is nearly 36 times more than 10 million tonnes in 1970. In addition, looking at containerized freight, about 19 million TEUs were handled in 2015 and it is almost six and a half times more than 2.3

Table A-3 Changes in port facility and port performance over time in the Port of Busan

		1971	1981	1990	2000	2010	2015
Quay wall	Length (m)*	4,600	7,420	13,533	21,052	30,609	29,285
	Berths	33	52	81	108	162	123
	Length per berth	139	143	167	195	189	238
Yard (1,000 m²)		-	-	-	1,805	2,578	2,610
Distriparks (1,000 m²)		0	0	0	0	1,010	6,794
Ship Callings	Number	40,290	24,679	37,419	72,022	104,995	98,087
	Tonnage (1,000 D/T)	-	-	225,036	485,040	936,418	1,247,878
	Tonnage per ship	-	-	6,014	6,735	8,919	12,722
Cargo traffic	Total (1,000 R/T)	10,902	29,716	63,371	117,229	262,070	359,676
	Container (1,000 TEU)	-	-	2,348	6,383	14,194	19,469

Note: * lengths of quay wall in 1971 and 1981 are estimated by multiplying the standard length per berth in the criteria of the port construction, which is from the MOF (2014) to the number of berths by size which is from KMPA (1991). Some data denoted by (-) are not found before 1990 but the data in the category of 'distriparks' began to be made since the late 2000s.
Source: compiled by author from MOF (2016a), MOF (2016b), MLTM (2011a), MOMAF (2004), MOMAF (2001), KMPA (1991) and SPIDC.

Figure A-2 Regional proportions of trade freight handled in the Port of Busan



Note: data of container freight is surveyed in 2005 and one of bulk cargo traffics is in 2004.
Source: Korea Transport Database (KTDB) in Korea Transportation Institute (KOTI).

million TEUs in 1990. Compared to 1971, the growth rate must be more than a thousand percent. It is clear that the growth rate of port utilization is much higher than one of the port facilities.

In the sight of the service scope of the port, the regional composition examined by the origination and the destination of cargos can supply the valuable information as shown in Figure A-2. The data supply the regional composition by full container cargo and general bulk cargo which is including L.C.L cargo[160]. According to KTDB (2005), as both the origination and the destination, more than 75% out of the total container cargo is rooted in three regions: Gyeongnam (36.5%), Gyeongbuk (19.14%) and Capital area (19.05%). Busan accounts for about 7% of the containerized freight, which is slightly higher than one of Jeonnam. On the contrary, in the case of general bulk cargo, more than 80% of the total transport is related in three areas including Busan (32.46%), Gyeongnam (28.49%) and Gyeongbuk (20.60%). In following, the capital area accounts for 9.10% which is significantly lower than one of the containerized freight.

From the data, it is clear that the port has played a role as the gateway across the country. Firstly, it can be seen that the port is used from and/or to all over the country, although the regional ratio of the capital area is quite lower in the case of general bulk cargo than one in the containerized freight. In addition, the cargo generated in Busan is likely to be transported directly to container freight station (CFS) nearby or inside of the port area before filled in and after unfilled from a container. It means that the end users in Busan have various choices to transport the importing and exporting cargos. On the contrary, ones in other regions are likely to prefer to transport the cargo with a container filled with L.C.L cargo.

A.2.1.4 Summary

To summarize, the Port of Busan, which has a 140-year history as an international port since the opening in 1876, is the gateway of Korea and one of the hub ports in Northeast Asia through continuously developing port facilities for the last 5 decades. In addition, the Port of Busan can be evaluated as follows in the sight of the port development stage, the relation with the city, the functional status in the port system.

First of all, in the sight of the port development stage, the port is evaluated to step to the additional stage; so-called the phase of a new port, which can’t be explained through applying the morphological approach suggested by Bird (1963) and modified by Notteboom and Rodrigue (2005). The port seems to already experience three typical phases as discussed in previous part; the phase of setting by the 1960s, the second phased of expansion by the mid-1980s, and the third phase of specialization by the mid-2000s. In addition, it seems to be unreasonable that the port is understood

[160] L.C.L stands for ‘less than carload lot’ and is used for the cargo that the amount is too small to full a container. L.C.L. cargos are usually filled in a container and unfilled in CFS nearby container wharfs.

to be in the phase of expansion one more time, as considering that New Port is quite bigger than North Port both by the size of a wharf and amount of annually handled freights.

Secondly, in the sight of the interaction with the city, the port has been in the relationship that the port and the city are not only mutually independent but also both cooperative and conflicting at the same time in terms of economic growth and spatial expansion. It is clear that Busan has grown to become the second largest metropolitan city in Korea thanks to the opening and the growth of the port (Woo, 2009). On the one hand, the city has enjoyed the growth in almost all factors as the gateway while the export-oriented growth strategies have been implemented (Jung, 2011). On the other hand, the port could have developed without any withdrawal thanks to the growth of the city with regard to both the supply of factors and the demand for the service; especially, well-educated employments (Woo, 2010). Meanwhile, the interface between the port and the city is rapidly getting smaller in North Port due to the redevelopment project but continuously bigger in New Port.

Finally, in the viewpoint of the functional role, the port is still playing as the gateway of Korea, while supplying the service even to the capital area whose share is almost 20% out of the total volume of trading containerized freights; however, the regional share of the capital area has decreased gradually as the port facilities have developed in other ports (KTDB, 2011). In addition, the port has played as one of the hub ports in Northeast Asia through supplying the transhipment service to global shipping liners.[161]

[161] The amount of transhipped container freights is 10.11 million TEUs which is around 52 % out of the total amount of 19.47 million TEUs in 2015.

A.2.2 Port of Incheon

A.2.2.1 Port development

Figure A-3 shows where both the port and four sub-divisions are located and when each port facility is developed. Based on the information, the development trajectory of the port can be understood in the frame of the morphological expansion as below.

As the first phase, the setting is the period that the port had settled down nearby the location of Pier 1 as a modern port; from the 1910s when the 1st dock was built nearby Sinheung-dong[162] to the mid-1970s when the 2nd dock and the lock gate were constructed. The port facilities constructed during this period include the 1st and 2nd dock and the lock gate of Inner Port which is denoted by 1, 2, and 3 in the blue circle.

As the phase of expansion, the port had increased the facilities centred on Inner Port thanks to the construction of the lock gate since the mid-1970s to the end of the 20th century. The government had intensively constructed port facilities in order to meet the demands for port facilities rather than to increase the operational efficiency of port facilities by freight types. During this period, existing port facilities such as the 1st and 2nd dock were renovated to the shape of a pier and new port facilities with linear quay wall such as Pier 4, Pier 5, Pier 6 and Pier 7, were developed gradually.

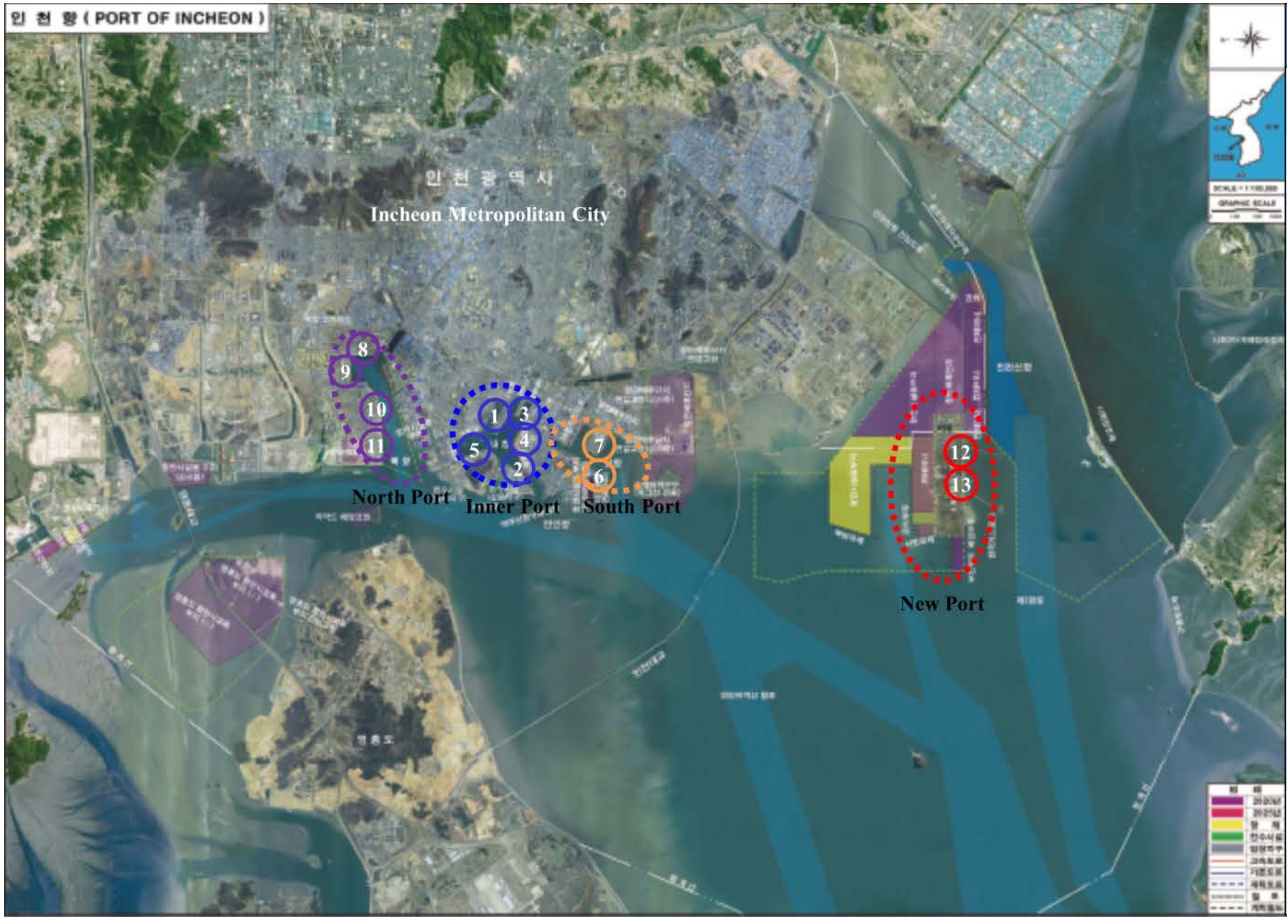
As the era of specialization, the port has expanded its districts by building new facilities and moving international cargos by type into South Port, North Port and New Port, as entering the 2000s. In order to enhance the operational efficiency of existing port facilities and cope with the issues such as the enlargement of ships, the spatial limitation of port districts, and heavy congestions, the port has expanded and specialized the facilities at the same time (KPHA, 2011). Various bulk cargoes were transferred to North Port, and liquid cargo and some container cargo were transferred to South Port (MLTM, 2011a). In addition, in order to deal with increasing container cargo, New Port was partially opened in 2015.

A.2.2.2 Interaction with the city

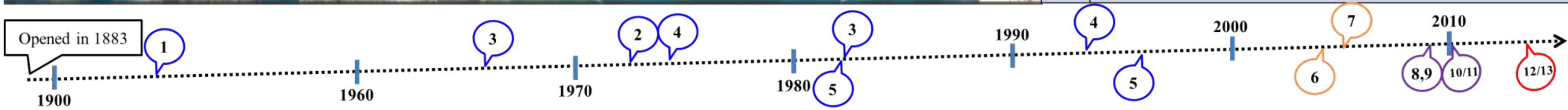
In the sight of the interaction between the port and the city, the port has been in the close but changed relationship with the city; especially, in the point of the spatial expansion. The interaction is overviewed with the development phases of the port focused.

[162] Sinheung-dong is located in the centre of Jung-gu and was the CBD of Incheon by the 1970s.

Figure A-3 Map and a brief history of the port development of the Port of Incheon



No	Contents
1	**Pier 1 (1,799m)**: constructed from 1911 to 1923 as a dock and renovated as a pier and expanded with **Pier 8 (1,152m)** in 1985
2	**Lock gate of Inner Port**: constructed since 1970, operated in 1974
3	**Pier 2 (1,278m)**: constructed as a dock in the 1960s and renovated as a pier in 1983 (328m) and fully opened in 1983
4	**Pier 3 (1,250m):** opened in 1974 **Pier 4 (1,160m):** opened in 1974 **Pier 5 (1,150m):** opened in 1993
5	**Pier 6 (1,218m):** opened in 1996 **Pier 7(1,216m):** opened in 1982
6	**Incheon Container Terminal (ICT, 600m)**: operated in 2004
7	**Seongwang Container Terminal (SICT, 407m)**: operated in 2005
8	**Timber Wharf (450m)**: constructed since 2003, opened in 2008
9	**General Cargo Wharf (1,400m)**: constructed since 2005, opened in 2009
10	**Multi-purpose Wharf (770m)**: opened in 2010
11	**Dongbu Incheon Wharf (840m)**: opened in 2010
12	**Hanjin Wharf (800m)**: partially opened in 2015
13	**Seongwang New Container Terminal (800m)**: partially opened in 2015



Source: compiled by author from KPHA (2011), MLTM (2012a), MLTM (2011a), MOF (2016b), MOF (2016a), and IPA website (2017), etc.

According to IMC (2004), around the opening of the Port of Incheon, Incheon was only a small town consisting of the harbour and foreign settlement area. In this period, the city is necessary due to the port. However, with the continuous growth of the port, Incheon had expanded in terms of both the jurisdiction and the population. In the 1910s, Incheon had a jurisdiction of 605 ha as a small town with a population of 29 thousand. Since then, Incheon had grown to become a metropolitan city.

While the port had expanded continuously by the mid-1970s, Incheon had also rapidly grown. The city had formed a metropolitan city whose CBD was located in the area nearby the port with a population of over one million at the end of the 1970s. Especially, the construction of Gyeong-in Expressway, connecting Seoul and the city in the 1970s, contributed to accelerating the spatial expansion and the population increase in Incheon (IMC, 2004). As a result, urban functions concentrated nearby the port until the 1970s have spread out the eastern part of Incheon, and the spatial expansion of Incheon continued. With the expansion of the port, industrial complexes were built on the outskirts of Incheon. In addition, the second Gyeong-in Expressway was opened in 1990 and Incheon international airport was opened in 2001. In 2002, Finally, Incheon grew into the 3rd largest metropolitan city, following Seoul and Busan, with a population of 2.5 million (IMC, 2004).

However, as the development of Inner Port was completed in the late 1990s, conflictions between the port and the city due to the spatial limitation and heavy congestions pushed the port to move the third phase to build port facilities outside of Inner Port. As the port entered the phase of the specialization since the 2000s, the facilities have been expanded on a large scale focusing on redistributing the functions to South Port, North Port and New Port while considering the urban planning of the regional government (MOMAF, 2001).[163] Finally, the interaction between the port and the city stepped in the phase that the port is developed and managed in the line with the growth strategy of the city, after experiencing the phases that the port attracted the growth of the city and that the port and the city contributed mutually. Meanwhile, as port facilities expand beyond Inner Port, the pressure from the regional stakeholders with regard to the redevelopment of some parts of Inner Port has been increased. As a result, the central government has accommodated sharply conflicting requests among various stakeholders and planned the strategy for the redevelopment considering the various requests since the early 2010s (MOF, 2016a).

A.2.2.3 Status of the port

As shown in Table A-4, it is clear that the port has grown extremely fast for the last 45 years in terms of both port facilities and port utilization. In aspects of port facilities, as of 1971, the total quay wall,

[163] The function to handle bulk cargos was planned to move to North Port nearby the industrial complex. South Port and New Port, which had been the tidal flat areas, focus on the liquid cargo and the containerized cargo as considering that the urban area was very close. In addition, Songdo Free Trade Zone was developed through the large scale of landfill construction around the tidal flat areas between the existing urban area and New Port.

which was 760m long, could accommodate seven ships by the designed criteria. After then, the port facilities have been increased prominently every ten years, as the port development has progressed in earnest. As of 2015, the total quay wall, which is 24,539m long, can accommodate 117 ships at the same time by the designed criteria.

Looking at the key objective of port development policies over time, what is interesting is that the number of berths increased significantly until 2000. As a result, the average length of the quay walls in the port was less than or around 170m by 2000, but has rapidly increased after the 2000s and reached 210m by 2015. This can be understood as a result of a large increase in the size of the wharf due to the opening of container dedicated wharves in New Port and multi-purpose piers in South Port and North Port.

In the sight of port utilization, the port has experienced the skyrocketing increase in terms of ship callings and the amount of freight handled. On the one hand, the number of ship callings has increased from 22,442 times in 1970 to 37,560 times in 2015. The growth rate is around 70% and seems to be quite small compared to the growth of port facilities, which is around 3,000%. However, as looking at the total weight of vessels, the growth rate is much bigger; namely, the total weight, which is 378 million tonnes in 2015, has increased by almost several times compared to one in 1990. As a result, the average weight per ship in 2015 is almost twice as big as one in 1990.

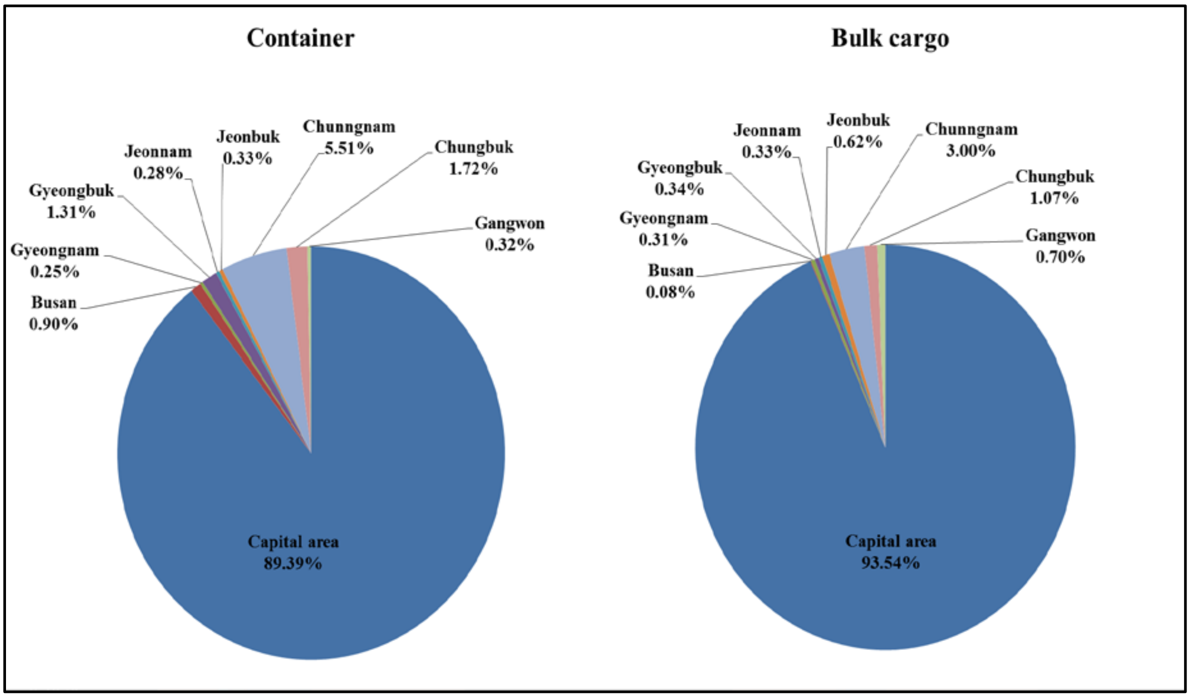
On the other hand, the annual amount of handled freight is 157 million tonnes in 2015, which is nearly 17 times as big as 9.3 million tonnes in 1970. In addition, looking at container cargo, about

Table A-4 Changes in port facility and port performance over time in the Port of Incheon

		1971	1981	1990	2000	2010	2015
Quay wall	Length (m)*	760	5,280	7,895	10,802	17,425	24,539
	Berths	7	30	48	75	103	117
	Length per berth	109	176	164	144	169	210
Yard (1,000 m²)					1,848	2,578	4,139
Distriparks (1,000 m²)						568	855
Ship Callings	Number	22,442	25,634	44,785	44,944	42,563	37,560
	Tonnage (1,000 D/T)			106,198	240,086	339,829	378,218
	Tonnage per ship	0	0	2,371	5,342	7,984	10,070
Cargo traffic	Total (1,000 R/T)	9,343	24,070	60,337	120,399	149,785	157,624
	Container (1,000 TEU)			112	611	1,902	2,377

Note*: lengths of quay wall in 1971 and 1981 are estimated by multiplying the standard length per berth in the criteria of the port construction, which is from the MOF (2014) to the number of berths by size which is from KMPA (1991).
Source: compiled by the author from MOF (2016a), MOF (2016b), MLTM (2011a), MOMAF (2004), MOMAF (2001), KMPA (1991) and SPIDC (2017).

Figure A-4 Regional proportions of trade freight handled in the Port of Incheon



Note: data of container freight is surveyed in 2005 and one of bulk cargo traffics is in 2004.
Source: KTDB, the website of KOTI (2017).

2.3 million TEUs were handled in 2015 and it is almost 23 times as many as 112 thousand TEUs in 1990. Nevertheless, it can be said that the growth rate of port utilization is slightly lower than the one of port facilities by the criteria of cargo traffics by R/T and the length of quay wall respectively.

In terms of regional compositions as shown in Figure A-4, most of the total cargos handled in the port are clearly dependent on the capital area. According to KTDB (2005), in the case of containerized cargo, about 95% out of the total cargo is rooted in the capital area (89.39%) and Chungnam (5.51%). In addition, in the case of general bulk cargo, the regional ratio of the cargo generated in the capital area is about 94%, which shows that the concentration on the capital area is much more severe. As a result, the port can be understood to play a role as the gateway to the capital area and has a relatively narrow service range.

A.2.2.4 Summary

In summary, the Port of Incheon, as having around 135-year history since the opening in 1883 and having developed port facilities for the last five decades, plays a role as the gateway of the capital area. The port can be understood to have its own status in terms of port development trajectory, the interaction of the city, and the functional role. Firstly, the port seems to have been in the third phase of specialization since the early 2000s through the first phase of setting until the mid-1970s and the second phase of expansion until the late 1990s. The port is still relocating the cargos and the function of port facilities from Inner Port to three other divisions according to the type of cargo (MLTM, 2011a). Secondly, from the perspective of the interaction with the city, the port had experienced various relationships with the city over time and today is mutually dependent on the city each other. Meanwhile, it can be said that the city can influence much more than the port can due to the size of the city; for example, the redevelopment project of Inner Port. Lastly, in the viewpoint of the port's function, it is clear that the port plays a role as the gateway of the capital area including Seoul and Gyeonggi and competes with the Port of Busan and the Port of Gwangyang in terms of container freight generated in the capital area (Choi and Kim, 2010).

A.2.3 Port of Ulsan

A.2.3.1 Brief history of port development

The map and the table in Figure A-5 show the location and the construction period of major facilities. Based on these, the development history of the port can be understood with the morphological methodology applied as belows.

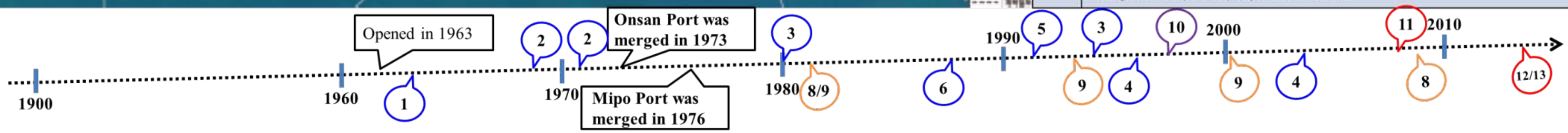
The first phase is the period of setting from when the port had been settled down nearby Pier 4 and to when the present port was shaped through integrating Onsan Port and Mipo Port. It can be said that the time period is mainly the 1960s and the mid-1970s. Port facilities constructed during this period are Pier 4, Pier 1, Pier 2 and Pier 3 in Main Port and some of Pier 8 and Pier 9 in Onsan Port, and some facilities in Mipo port. The port facilities during this period were to accommodate unscaled vessels, most of which are uneven dock facilities.

The second phase is the period that Main Port, Onsan Port, and Mipo Port were continuously expanded through extending new facilities near the existing port facilities. This is equivalent to the period from the 1980s to the mid-2000s. The port facilities constructed at this phase are not shaped like a perfect linear structure but characterized as a gradual extension along the waterline of rivers to accommodate the increasing ship callings. Key facilities built during this period are Pier 5, Pier 6 and many facilities for liquid cargo in Main Port, and most of the port facilities in Onsan Port. The important characteristic is that the port policy has focussed on increasing the loading and unloading capability based on the distributed arrangement according to the function of facilities (MOMAF, 2001). As discussed by Bird (1963), any port generally experienced the specialization of port facilities and the relocation of cargos by type. However, in the case of the Port of Ulsan, the stage of expansion is following the specialization. It is because three sub-ports had been developed under the special objectives to cope with the cargos from and to industrial complex (KPHA, 2011).

The last phase is the period with the expansion and the specialization appeared together since New Port began to be opened in the late 2000s (MLTM, 2011a). The port has moved the function of the old facilities to ones in New Port according to cargo type. In the morphological word, the port has extended port facilities from the river mouth to the coastal zone. In addition, port facilities have been developed on a large scale at the same time in order to accommodate the scaled vessels and improve the operational efficiency of existing port facilities. Port facilities built during this period include Ulsan New Port Container Terminal and the large-scaled facilities for liquid cargo; in particular, it is being promoted to the scale capable of berthing up to 300,000 tonnes of vessels.

Figure A-5 Map and a brief history of the port development of the Port of Ulsan

No	Contents
1	**Pier 4 (322m)**:the first pier which was opened after the designation of an open port, operated in 1964
2	**Pier 1, 2, 3 (149m, 602m, 347m):** opened in 1972, 1969 and 1971 respectively
3	**Pier 5 (220m)**: operated in 1980 **Pier 6 (990m)**: operated in 1994
4	**Pier 7 (210m)**: operated in 1996 **Pier 8 (375m)**: operated in 2003 **Pier 9 (150m)**: operated in 2004
5	**SK Oil Piers (1,422m)**: opened partially in 1991 and fully in 1997
6	**Ro-Ro Pier (830m):** opened partially in 1986 and fully in 1996
7	**Yeompo Pier (810m)**: operated in 2009
8	**Facilities for liquid cargo (7,783m)**: opened partially in 1980, fully in 2009
9	**Onsan Pier 1-4 (920m)**: opened partially in 1981 and fully in 1993 **Other Piers (2,280m)**: opened partially in 1981 and fully in 2000
10	**Mipo Pier (210m)**: opened in 1997
11	**Ulsan New Port Container Terminal (920m)**: opened in 2009
12	**Sebang Pier (240m)**: opened in 2013
13	**Korean Express Pier (210m)**: opened in 2013 **Dongbu Pier (210m)**: opened in 2013



Source: compiled by author from KPHA (2011), MLTM (2012a), MLTM (2011a), MOF (2016b), MOF (2016a), and UPA website (2017), etc.

A.2.3.2 Interaction with the city

In the sight of the interaction with the city, the port has quite different history from two previous ports. The port has the comparatively short history of 55 years as an international port since the opening in 1963 and has developed extremely strategically according to the export-oriented economic growth plan by the central government. By these characteristics, the port has such a unique relationship with the city compared to trading ports in western countries and even both the Port of Busan and the Port of Incheon.

According to Yoo (2012), in 1963 when the Port of Ulsan was designated as an open port, Ulsan[164] was only a remote rural area, whose main industries were agriculture and fisheries, with a population of 220 thousand. However, as large-scale industrial complexes were gradually built along the coastal and inland areas nearby the Port of Ulsan[165], the city had grown rapidly and continuously (KPHA, 2011). As a result, mainly thanks to the huge influx of the employment, the city had experienced the rapid population growth to reach 535 thousand in 1980 and 808 thousand in 1990. Ulsan continued to grow in the 1990s and it was promoted to a metropolitan city with a population of a million in 1997 (KOSIS, 2017). However, the direct relationship between the port and the urban area has not been quite strong due to the characteristic that the industrial complexes are located between the port district and the urban area (Heo and Lee, 2009). Meanwhile, as industrial complexes expanded to the inland area, the road congestion was getting severe through passing the 1990s and the 2000s. Considered these characteristics, the government has focused on both the improvement of the access to the expressway and the expansion of the space for port facilities (MLTM, 2011a).

Today, Ulsan is the seventh largest city in Korea, whose population was 1.2 million in 2015, with the third largest port on a handled freight basis. However, the interaction between the port and the city is neither quite close nor various in terms of spatial issues for the size of both. It can be said that the unique one is mainly based on the existence of coastal industrial complexes nearby the port district and the restricted role to support mainly those complexes.

A.2.3.3 Status of the port

As shown in Table A-5, it is clear that the Port of Ulsan has grown remarkably for 45 years in terms of port facilities and port utilization as a gateway of Ulsan and the northeastern area of Gyeongnam.

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[164] Ulsan was Ulsan-gun in Gyeongnam, which is a province, in 1962 and elevated to a city in 1963. And then, it became a metropolitan city which is independent from the province.

[165] Ulsan was designated in 1962 as the city where national industrial complexes were supposed to be developed, and today it became the biggest industrial city to represent Korea. Especially, several corporations which were located in the complexes such as Hyundai Motors, Hyundai Heavy Industries, and SK Refinery, became a global company.

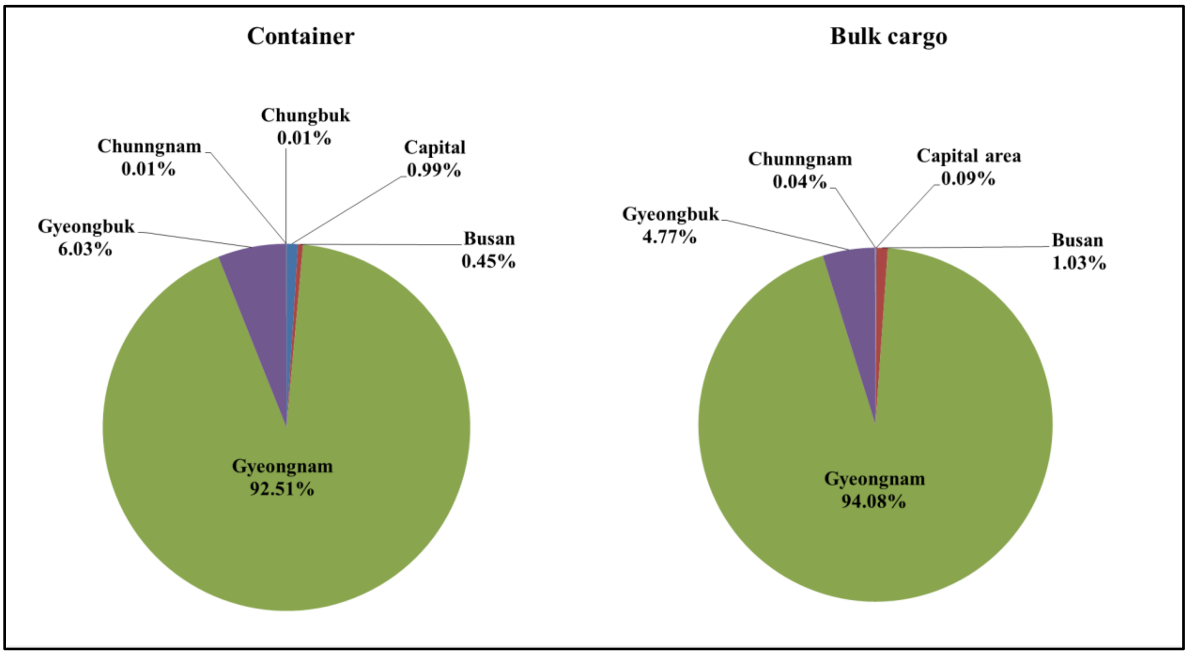
One the one hand, in terms of port facilities, as of 1971, the total quay wall, which was 1,463m long, could accommodate eight ships by the designed criteria. However, as the port development has progressed in earnest, it can be seen that the port facilities increased prominently every ten years. As of 2015, the total quay wall, which is 20,218m long, can accommodate 114 numbers of ships at the same time by the designed criteria.

Table A-5 Changes in port facility and port performance over time in the Port of Ulsan

		1971	1981	1990	2000	2010	2015
Quay wall	Length (m)*	1,463	2,130	5,324	8,607	18,038	20,218
	Berths	8	15	55	90	100	114
	Length per berth	183	142	97	96	180	177
Yard (1,000 m²)		-	-	-	377	1,082	1,287
Distriparks (1,000 m²)		0	0	0	0	0	84
Ship Callings	Number	7,044	17,445	26,971	48,496	50,975	51,525
	Tonnage (1,000 D/T)	-	-	118,962	306,040	387,226	438,801
	Tonnage per ship	-	-	4,411	6,311	7,596	8,516
Cargo traffic	Total (1,000 R/T)	11,653	22,971	51,169	73,320	171,664	190,870
	Container (1,000 TEU)	-	-	7	236	335	385

Note*: lengths of quay wall in 1971 and 1981 are estimated by multiplying the standard length per berth in the criteria of the port construction, which is from the MOF (2014) to the number of berths by size which is from KMPA (1991).
Source: compiled by the author from MOF (2016a), MOF (2016b), MLTM (2011a), MOMAF (2004), MOMAF (2001), KMPA (1991) and SPIDC (2017).

Figure A-6 Regional proportions of trade freight handled in the Port of Ulsan



Note*: lengths of quay wall in 1971 and 1981 are estimated by multiplying the standard length per berth in the criteria of the port construction, which is from the MOF (2014) to the number of berths by size which is from KMPA (1991).
Source: KTDB, the website of KOTI (2017).

Looking at the key objective of port development policies over time, what is interesting is that the number of berths has increased significantly by 2000, while the length of the quay has done after the 2000s. As a result, the average length of the quay walls has been decreased by 2000, but the average length rapidly increased after the 2000s to reach 177m by 2015.

In the sight of port utilization, the port has been in the skyrocketing increase in terms of ship callings and the amount of cargos handled. The number of ship callings has increased from 7,044 vessels in 1970 to 51,525 vessels in 2015. The growth rate seems to be much smaller than one of the lengths of the quay wall. However, as looking at the total weight of vessel vessels, the growth rate is much bigger; namely, the total weight which is 438 million tonnes in 2015 has increased by several times compared to one in 1990. As a result, the average weight per ship in 2015 is almost twice as big as one in 1990. The amount of cargos which is 190 million tonnes in 2015 is nearly 16 times as big as 11.6 million tonnes in 1970.

In the point of the regional composition of cargos, as shown in Figure A-6, the port can be understood clearly to be specialized as the port to support industrial complexes mainly in Ulsan and the northeastern area of Gyeongnam. According to KTDB (2005), about 98% of the total containerized freight is rooted in Ulsan and Gyeongnam (92.5%) and Gyeongbuk (6%). In the case of bulk cargo, about 99% of the total cargo is generated from and/or to Ulsan and Gyeongnam (94%) and Gyeongbuk (4.7%). In conclusion, considering that the proportion of containerized cargo is very low out of the total cargos in the port, most of the handled cargo can be interpreted to be generated inside of and around Ulsan.

A.2.3.4 Summary

To summarize, the Port of Ulsan, which has the 55-year history as an international port since 1963, has been playing its role as the supporting port for the industrial complexes in and nearby Ulsan; especially, it ranks at the top in terms of the annual amount of liquid cargo handled. Looking at the characteristics in detail, the port can be evaluated as follows in three aspects of port development trajectory, the interaction of the city, and the functional role. Firstly, in the viewpoint of the port development stage, the port can be evaluated not to have undergone general steps of setting, expansion and specialization. The port has been developed strategically through locating port facilities in accordance with the features of nearby coastal industrial complexes from the stage of port development planning. Therefore, it can be concluded that the first phase of setting and the third phase of specialization proceeded at the same time. And then, the port stepped in the next phase of expansion in the way that new facilities are gradually extended nearby the existing facilities with similar functions. In addition, the port has the characteristics of a river port and a coastal port because it was formed at the riverside and expanded the coastal area beyond the estuary. Secondly, in terms of the relationship with the city, the port has not had a strong direct interaction with regard to the demands for space because coastal industrial complexes have blocked the interface between the port and the city. Lastly, in the viewpoint of functional roles, the port can be evaluated as the port that is servicing for regional demands; especially, demands in and nearby Ulsan, and specialized at the liquid cargo, even though the port is ranked at the fourth on the annual amount basis of freight handled.

A.2.4 Port of Gwangyang

A.2.4.1 Brief history of port development

The location and the development history of major facilities are shown in Figure A-7. Based on this figure, the history of port development can be understood in three stages classified.

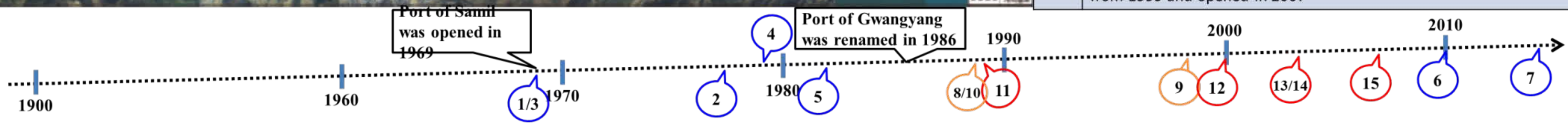
As the first stage, the setting can be defined as the period that the Port of Yeocheon had settled down as an international trading port at the mid area of Yeousu district, which can be considered as the birthplace of the Port of Gwangyang. This is correspondent to the period from 1969 when the port is opened to the mid-1980s when the POSCO steel plant was built. The facilities constructed during this period include some of the facilities denoted by 1 to 5 in the blue circle and are mainly dedicated facilities for liquid cargoes. Especially, it can be said the phase of specialization had partially been implemented with the phase of setting at the same time, considered that the facilities for liquid cargoes are mainly located at the outer area where the water depth is easy to secure and the facilities for petrochemical products are arranged nearby the industrial complex.

Subsequently, the second phase is classified from 1986 when the name of the port was changed to the end 1990s when container dedicated wharves began to be opened. During this period, new facilities with similar functions were gathered and extended nearby the existing facilities in Yeosu district, while port facilities of POSCO began to be established and operated in the line of the specialized expansion. The facilities built during this period include Piers for raw material, Ro-Ro Pier, and Product Pier located in POSCO. Those facilities are characterized by the fact that they were constructed for accommodating rapidly enlarged vessels in the relation to the end user who is both a shipper and a manufacturing corporation. By this reason, the port had been functioning as a supporting port for industrial complexes: in fact, port facilities are specialized for the liquid cargo and the petrochemical products in Yeosu district and the raw materials and the steel products in Gwangyang district.

The last phase is the period that the port has played a role as an independent trade port since the 2000s, as several container dedicated wharves were gradually opened in Gapo district. The container wharfs developed during this period aimed to accommodate large-scale vessels of 10,000 TEU or more. As a result, the port has become the port that provides service to cargoes generated not only in industrial complexes nearby the port but also to all regions of the country including the capital area. In another word, the port has the third axe to support the growth of the port; liquid cargo and its products in Yeosu, steel-related cargos in Gwangyang, and container cargos from and to the whole country.

Figure A-7 Map and a brief history of the port development of the Port of Gwangyang

No	Contents
1	**GS No. 1 Pier (817m)**: the first port facility in the Port of Samil, opened in 1969 (430m) and expanded in the 1980s and the 1990s
2	**Nakpo Pier (210m)**: constructed from 1974 to 1976, partially opened in 1977 and fully opened in 1979
3	**Crude Oil Pier (1,228m)**: the first pier was opened in 1969, the second and the third were expanded in 1981 and 2011 respectively
4	**Jungheung Pier (560m)**: opened in 1979 and expanded by 260m quay wall in 1992
5	**LPG Pier (210m)**: opened in 1982
6	**Yeosu Thermal Coal Pier (210m)**: opened in 2010
7	**Yeocheon General Pier (420m)**: constructed through expanding seaside of idle coastal area and opened in 2014
8	**Raw Material Pier (2,732m)**: constructed from 1984 and fully opened in 1990
9	**Ro-Ro Pier (380m)**: opened in 1998
10	**Product Pier (1,908m)**: constructed from 1984, operated partially in 1988 and opened berth by berth in the 1990s and the 2000s
11	**Jungma General Wharf (420m)**: opened in 1988
12	**Hapo General Wharf (1,400m)**:constructed by KCTA from 1987 and opened in 2000
13	**The 2-1 Phase of Container Wharf (1,150m)**: constructed by KCTA from 1995 and opened in 2004
14	**The 2-2 Phase of Container Wharf (1,150m)**: constructed by KCTA from 1995 and opened in 2004
15	**The 3-1 Phase of Container Wharf (1,400m)**: constructed by KCTA from 1999 and opened in 2007



Source: compiled by author from KPHA (2011), MLTM (2012a), MLTM (2011a), MOF (2016b), MOF (2016a), and YGPA website (2017), etc.

A.2.4.2 Interaction with the city

The port is mainly located in three different cities in Jeonnam; the City of Yeosu, the City of Gwnangyang, and the City of Sucheon, unlike the other three ports which is mainly based on a metropolitan city. For this reason, in order to understand the interaction with the city, it is necessary to look over the changes in three cities following the expansion of the port over time.

On the one hand, the Port of Yeocheon (formerly Samil Port), which became the birthplace of the Port of Gwangyang, was a small port which was located in the city of Yeosu in 1967. At the time, Yeosu was a fishing small town with a population of 258,000, but Yeosu National Industrial Complex began to be installed in 1967 and Yeosu rapidly changed into an industrial city (Kang, 2004). However, the total population of Yeosu has not changed by a huge amount: for example, 306 thousand in 1980, and 289 thousand in 2015, as the population in rural areas rapidly decreased (KOSIS). On another hand, Gwangyang has experienced the steady increase in the population; namely, 90 thousand in the early 1980s, 132 thousand in 2000, and 153 thousand in 2015. Anyway, Gwangyang has changed its status from rural area to small but urbanized city with the size enlarged in terms of the population and the regional economy (KOSIS, 2017). On the other hand, Suncheon, which Yulchon district is located in, was a small and medium-sized city with a population of 245 thousand in the mid-1980s when the name of the port was changed. Meanwhile, the city has maintained the similar status in the population of 281 thousand (KOSIS, 2017).

From the perspective of the relationship between the port and the city, it is remarkable that the port development policy had focused on supporting industrial activities which took place in the industrial districts in the first and second phases of the port development trajectory. This characteristic is quite similar to the Port of Ulsan in the sight of the spatial structure and the role of port facilities. This suggests that the Port of Gwangyang has not had a strong direct relationship with Yeosu and Gwangyang due to the fact that the industrial complex had been located between the port district and the urban area (MOF, 2016a). In addition, the growth of the city had been dependent not on the growth of the port but the growth of the companies in the industrial complexes. On the other hand, it can be said that the port has built the wider interface and the stronger interaction with Gwangyang since the 2000s when container dedicated facilities have been built on a large scale; especially, mainly in the direction that the growth of the port contributes to the growth of the city.

A.2.4.3 Status of the port

As shown in Table A-6, it is clear that the Port of Gwangyang has grown remarkably for 45 studied years in terms of port facilities and port utilization. In terms of port facilities, as of 1981, the total quay wall, which was 1,650m long, could accommodate 12 ships by the designed criteria. However, as of 2015, the total quay wall, which is 23,041m long, can accommodate 99 ships at the same time by the designed criteria. Both the number of berths and the length of the quay wall have increased continuously by 2015. As a result, the average length of the quay walls in the port was less than 140m in 1981, but rapidly and continuously increased to reach 233m by 2015. This can be understood as a result of a large increase in the size of the wharf facility, regardless of the type of wharf.

In the sight of port utilization, the Port of Gwangyang has been in the skyrocketing increase in terms of ship callings and the annual amount of freight handled. The number of ship callings has increased from 7,650 vessels in 1981 to 48,229 vessels in 2015. The growth rate seems to be quite small compared to the growth of port facilities. However, as looking at the total weight of vessel vessels, the growth rate is much bigger; namely, the total weight which is 106 million tonnes in 2015 has increased more than one of the number of ship callings. As a result, the average weight per ship in 2015 is almost three times as much as that of 1990. Meanwhile, the freight traffic is 272 million tonnes in 2015, which is nearly 15 times as big as 18 million tonnes in 1980.

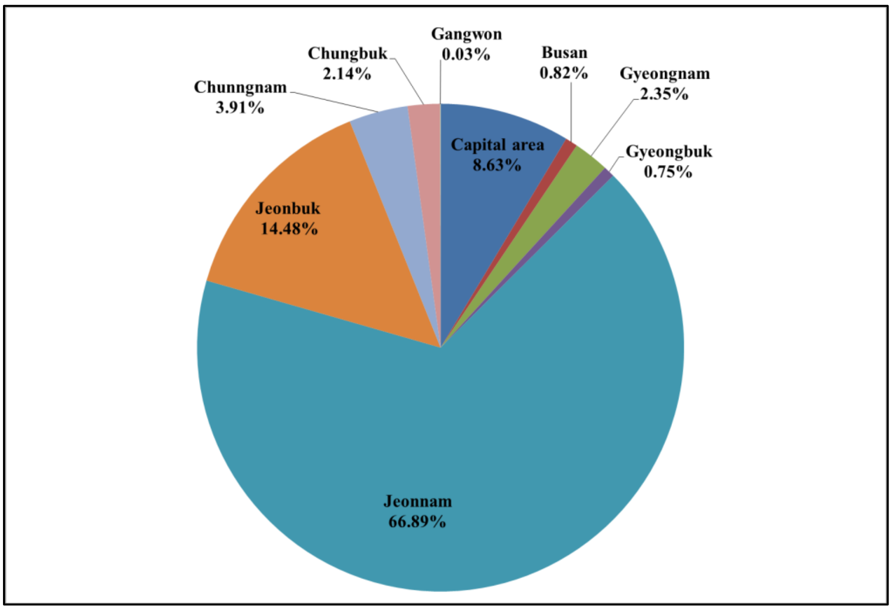
On the other hand, in the point of the regional composition of cargos handled in the port as shown in Figure A-8, the port has the totally different status and role by the type of cargo. According to NTDB (2005), most of the bulk cargo handled in the port is rooted in industrial complexes close to the port such as Yeosu Industrial Complex. On the other hand, in the case of the containerized cargo, more than 90% out of the total is rooted in Jeonnam (67%), Jeonbuk (15.5%) and the capital area (9%). As well, Chungnam and Gyeongnam are following by about 3%. From the data, it can be seen that the port serves not only as a supporting port for nearby industrial complexes but also as a gateway for the country, even though the role as a gateway is relatively limited compared to one of the Port of Busan.

Table A-6 Changes in port facility and port performance over time in the Port of Gwangyang

		1981	1990	2000	2010	2015
Quay wall	Length (m)*	1,650	6,338	12,138	18,167	23,041
	Berths	12	39	58	80	99
	Length per berth	138	163	209	227	233
Yard (1,000 m²)		-	-	377	2,077	1,999
Distriparks (1,000 m²)		0	0	0	1,032	1,367
Ship Callings	Number	7,650	23,847	38,920	45,813	48,229
	Tonnage (1,000 D/T)	-	106,215	271,399	482,240	703,176
	Tonnage per ship	-	4,454	6,973	10,526	14,580
Cargo traffic	Total (1,000 R/T)	18,435	64,263	74,516	206,691	272,007
	Container (1,000 TEU)	-	-	677	2,087	2,327

Note*: lengths of quay wall in 1971 and 1981 are estimated by multiplying the standard length per berth in the criteria of the port construction, which is from the MOF (2014) to the number of berths by size which is from KMPA (1991).
Source: compiled by the author from MOF (2016a), MOF (2016b), MLTM (2011a), MOMAF (2004), MOMAF (2001), KMPA (1991) and SPIDC (2017).

Figure A-8 Regional proportions of container freight handled in the Port of Gwangyang



Note: data of container freight is surveyed in 2005.
Source: compiled by the author from KTDB, the website of KOTI (2017).

A.2.4.4 Summary

To summarize, the Port of Gwangyang with the 50-year history as an international port since 1967 has played a role mainly as the supporting port for the industrial activities and partially as the auxiliary gateway deconcentrating container freight from the Port of Busan. Looking at the characteristics in detail, the port can be evaluated as follows in three aspects of port development trajectory, the interaction of the city, and the functional role. Firstly, in the perspective of port development, it can be evaluated that the port had not followed the general steps of setting, expansion and specialization. The port has been developed strategically through locating port facilities in accordance with the nature of nearby coastal industrial complexes from the stage of port development planning. As a result, the first phase of setting and the third phase of specialization proceeded at the same time, and then, the similar facilities have been extended step by step by. Secondly, in the viewpoint of the interaction with the city, it is not until the 2000s when the container related facilities began to be opened that the port began to make a direct interaction with the city with regard to the interface and the functions. Basically, the city had maintained the interface with the industrial districts rather than port districts because the former is encompassing the latter. Meanwhile, it can be said that the interaction with the city after the 2000s has been in the line that the port contributed the city much more than the opposite. Lastly, in the viewpoint of the functional roles, the port is highly subject to the shippers based on the industrial complexes in Yeosu and Gwangyang, but it has been reinforcing its status as the trade port with a nationwide service boundary centred on container logistics.

Appendix 3 Research Methodology

A.3.1 Social savings

The standard methodology to measure the social welfare is consumer surplus. According to Leunig (2010), under the assumption that the marginal benefit decreases with output and the cost are determined by competing uses for the resources, consumer surplus can be calculated as the area between the demand curve and the price, which means the willingness to pay over the total cost.

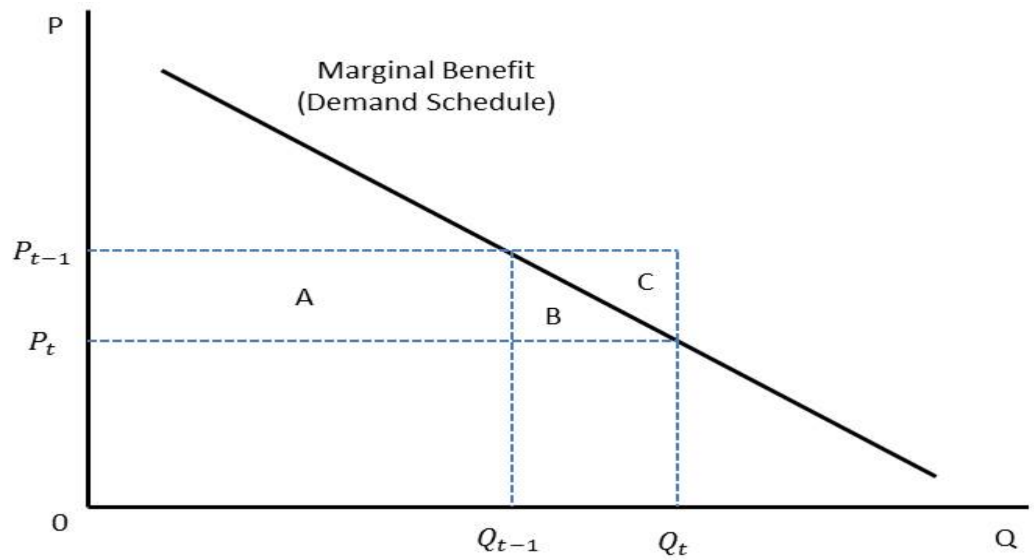
If a new technology would contribute to the decrease of the price and the increase of the quantity, the change of social welfare or the rise in consumer surplus can be represented the sum of A and B in Figure A-9. Area A is calculated by multiplying the fall in price ($P_{t-1} - P_t$) and the previous quantity sold (Q_{t-1}) and the area B is measured by the fall of the price ($P_{t-1} - P_t$) and the rise of the quantity ($Q_t - Q_{t-1}$). The exact figure in the change of consumer surplus will depend on the shape of the demand curve. This can be presented algebraically by

$$\Delta Consumer\ surplus = (P_{t-1} - P_t)Q_{t-1} + \alpha(P_{t-1} - P_t)(Q_t - Q_{t-1}) \qquad \text{A-1)}$$

where, P : price, Q : total quantity, t : post-innovation, $t-1$: pre-innovation, α : a parameter determined by the shape of the demand curve (this is ½ in the case of a linear demand curve).

In principle, the change in consumer surplus is the best way to measure the economic effects of a new technology: however, it is hardly applied in practice because of the requirement of costly data. As such, it is social savings that are a methodology applied instead of it by adding the assumption that the market is perfectly competitive (Leunig, 2010).

Figure A-9 Comparison between consumer surplus and social savings



The concept of social savings, which is introduced by Fogel (1962), can be defined as ‘the cost-savings of the new technology compared with the next best alternative’ (Crafts, 2004, p. 1) or ‘how much extra society would have to pay to do what it did after an innovation, without it’ (Leunig, 2010, p. 776). Even though the concept of social savings is based on the sight of the cost-saving, the way to measure the size of social savings is similar to the way to measure the change in consumer surplus, based on the assumption of the perfectly competitive market. Specifically, social savings can be understood the area A, B, C in Figure A-1, compared to consumer surplus (A, B). The concept can be presented by

$$social\ savings = (c_{t-1} - c_t)Q_t \qquad \text{A-2)}$$

where, c : marginal cost and all other notation remains the same.

Thanks to the assumption of the perfectly competitive market, the equation 21 can be changed the equation 22 as

$$social\ savings = (P_{t-1} - P_t)Q_t \qquad \text{A-3)}$$

where, all other notation remains the same.

Based on the simplest concept above, the way to measure social savings has diversified depending on the shape of the demand curve and the structural characteristics of the market (see Crafts, 2004, p. 8-11). According to Crafts (2004), a number of authors have devoted to analysing the contribution of a new technology to the economic growth via applying social savings (Hawke, 1970, Fogel, 1979, Oliner and Sichel, 2000, Bayoumi and Haacker, 2002) since Fogel (1962) introduced the concept.

Thanks to the efforts, the concept of social savings has lots of strengths as the methodology to analyse the economic impacts of a new technology compare to growth accounting (Crafts, 2004). First of all, the concept of social savings is clearly focusing on the benefits to users and social welfare from consumption rather than production. Secondly, this concept is quite useful and appropriate to evaluate the technological improvements in open economy situations. Finally, it is not needed to measure output in the sector which uses the new technology so that it can be applied when data are too limited (Leunig, 2010): especially, this is convenient where 'hard-to-measure' activities are concerned.

On the other hand, Leunig (2010) supplies the history of the debates related to the social savings approach since it was introduced by Fogel (1962). The first criticism is concerned with the implicit assumption that the relationship between price and marginal cost is constant and the price is set by the marginal cost with the old technology applied even after the appearance of a new technology (McClelland, 1968). The second one is the objective or the scope which is analysed by the social savings approach. This approach is clearly focusing on measuring only the gain to direct beneficiaries of improved technology (David, 1969): especially, railway or transport. He suggested that transport-using industries could lead to benefits 10 times the estimates of social savings through economies of scales. The third one is that this methodology doesn't supply any information about the changing structure of the economy (Williamson, 2008). The last one is related to the research fields which this methodology has been applied in. Leunig (2010) insists that 'the majority of social savings estimates relate to railways, and railways are the only technological improvement that have been extensively analysed using the social savings methodology'(p. 794) while he shows the several cased in non-railway situations: steam engines in 1800 (Von Tunzelmann, 1978), a turnpike by 1815 (Bogart, 2009), the product innovation of Ford (Hounshell, 1985), technological improvements of jet aircraft (Sutton, 1996), and ICT revolution (Oliner and Sichel, 2000) etc.

A.3.2 Input-Output *a*nalysis

One feature of the modern economies is that the transactions in all goods and services are getting more increased and complicated among industries and regions; even nations due to the globalisation. As a result, each industry has applied lots of materials or services from the other industries as the inputs. It is the Input-Output tables (henceforth IO tables) that are the matrix form which these economic flows are broken down in order to show the production and consumption interdependencies at among industrial sectors at the regional and national level. The IO tables are based on the assumption[166] that average IO relationships apply to a marginal change (Gretton, 2013, p. 4).

According to The Bank of BOK (2016, BOK), IO tables disaggregate the economic activities in all goods and services between industries as the form of a sale and a purchase within a specific region during a given period of time, which is normally one year. The Input-Output analysis (henceforth IO analysis) is the economic methodology which is to investigate the relationship or the interdependency between industries by the quantitative method based on the IO tables. For this reason, the IO analysis can show the production of interdependencies between industries and both the relationship between primary input factors and industries and the transactions between final demand sectors and industries. In addition, the IO analysis is consistent with the characteristics of the IO tables; for instant, the assumptions, advantages and disadvantages.

[166] The basic assumption can be consistent only if further assumptions below are applied;

- there is a fixed input structure in each industry, described by fixed technological coefficients,
- all products of an industry are identical or are made in fixed proportions to each other,
- each industry exhibits constant returns to scale in production,
- there is unlimited labour and capital available at fixed prices: so that, any change in the demand for productive factors will not induce any change in their cost, and
- there are no other constraints, such as the balance of payments or the actions of government, on the response of each industry to a stimulus.

Figure A-10 Structure of IO table (The Bank of Korea)

		Endogenous areas		Exogenous areas				Imports	Total output
		$1 \cdots n$	Total intermediate demand	Consumption	Investment	Exports	Total final demand		
Endogenous areas	1	$a_{11} \cdots a_{1n}$	ID_1	$C_1 \cdots$	$I_1 \cdots$	E_1	FD_1	IM_1	Y_1
	i	$a_{i1} \cdots a_{in}$	ID_i	$C_i \cdots$	$I_i \cdots$	E_i	FD_i	IM_i	Y_i
	n	$a_{n1} \cdots a_{nn}$	ID_n	$C_n \cdots$	$I_n \cdots$	E_n	FD_n	IM_n	Y_n
	Total intermediate Inputs	$A_1 \cdots A_n$							
Exogenous areas	Total value added	$V_1 \cdots V_n$							
Total inputs		$X_1 \cdots X_n$							

To see the IO table more concretely (see Figure A-10), it consists of both the cost components as inputs in the vertical direction and the demand constitution as outputs in the horizontal direction. In the vertical direction, the input components are divided into intermediate inputs (A) as endogenous areas which mean how each industry uses inputs from other industries and total value added (V) as exogenous areas which mean the input of labour and capital. On the other hand, the demand constitution, which means total demand to consist of the intermediate demand and the final demand, is represented in the horizontal direction.

Compared to the circulation process in a national economy, the IO analysis is to focus on the production structure behind the income circulation, while the national income analysis is to assess the economic activities in the sight of the income circulation. From the Figure A-2, two equations from the column and from the row are derived respectively below

$$ID + FD - IM = Y \qquad \text{A-4)}$$

$$A + V = X \qquad \text{A-5)}$$

where ID: intermediate demand, FD: final demand, IM: imports, Y: total output, A: intermediate inputs, V: value added, X: total inputs.

Based on an understanding of the IO table, it is not difficult to overview the IO analysis briefly. In general, the IO analysis can be implemented in two ways of demand-driven method and supply driven method in the analysis of economic impacts (Kwak et al., 2005). From the IO table and the equations above, the basic equations of the IO analysis can be expressed as

$$X_i = \sum_{j=1}^{n} X_{ij} + FD_i - IM_i = \sum_{j=1}^{n} a_{ij} X_j + FD_i - IM_i \qquad \text{A-6)}$$

$$X_j = \sum_{i=1}^{n} X_{ij} + V_j = \sum_{i=1}^{n} r_{ij} X_i + V_j \qquad \text{A-7)}$$

where X_i: the total output in sector *i = 1; …; n*; a_{ij}: direct input or technical coefficients which divide X_{ij} the inter-industry purchases of producing sector *i* from supply sector *j* by X_j total gross output in sector *j*, r_{ij}: direct output coefficients which divide X_{ij} the inter-industry purchases of producing sector *i* from supply sector *j* by X_i total gross input in sector *i*, and the other notation remains the same.

Thus, the equation A-6 describes the demand-driven model as viewing IO tables vertically, while the equation A-7 shows the supply-driven model as horizontally. From both equations, each theoretically elaborated approach in the IO analysis starts to be derived. With two ways, the IO analysis in practice mainly use the multiplier analysis to estimate three types of the economic effects[167], which are the direct effect, the indirect effect and the induced effect, and to sum up the total economic impacts of ports (Gretton, 2013, p. 4).

The IO analysis has been one of the most used methodologies which estimate the economic impact of port activities since the Port Economic Impact Kit report by Arthur D. Little and Pacific Coast Association of Port Authorities (1979) was published (Artal-Tur et al., 2015). A huge body of research has applied the IO analysis to quantify the economic impacts of ports on the regional economy thanks to the utility both of the IO table and of the IO analysis. In addition, as mentioned above as the concept of the IO tables, this methodology is quite powerful to understand the economic impacts of ports on the regional economy in the sight of the proportions of port activities in a regional economy at a given time (Chang, 1978). Furthermore, it is very powerful to understand the role of port activities in a national economy and the industrial relationship of ports with other industries (García and López, 2004)

On the other hand, it also has several drawbacks as the methodology to assess the changes over time and investigate if the contribution of ports on the regional economy is significant statistically. First of all, the IO analysis always encounters the criticism that it overestimates the economic impact due to both the strong assumptions[168] of the IO tables in principle (Gretton, 2013) and some limitations

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[167] Three effects can be defined below

- *the direct effect* is the change in the production, employment and value added of a specific industry required to *supply an additional unit* of final output of that industry;
- *the indirect effects* are the changes in the output, employment and value added of industries *supplying intermediate inputs* to the industry in question; and
- *the induced effects* are the changes in the output, employment and value added in *all stages of the production chain* required to support an additional unit of final output to the industry in question and its suppliers.

[168] These largely reflect the failure of the assumptions in the footnote 166 to hold in practice.

- Lack of supply-side constraints: multipliers assume that extra output can be produced in one area of activity without taking away resources from other activities.
- Fixed prices: so that effects of relative price changes play no role in the allocation of scarce resources between activities.
- Fixed ratios for intermediate inputs to production and outputs from production: so that changes in production technology and the use of inputs in production play no role in impact assessment.

in principle: for example, port activities are not grouped in a single category in SIC category (Davis, 1983) and arbitrary classification of direct, indirect and induced industry are needed (Dooms et al., 2015).

In addition, the IO analysis has further limitations due to the strong assumption and the basic characteristics of IO tables. Firstly, it doesn't consider technological changes in the transport system (Waters, 1977) due to the assumption of the IO tables that technical coefficients are fixed. Secondly, it is more adequate to investigate the static or comparative changes between two given time period than to assess the dynamic changes over time. Thirdly, even though the IO tables supply the annual data in every year at the moment, the IO table statistics were presented every five years (The Bank of BOK, 2016), so it can need high cost for data acquisition when the studied period is long (Shan et al., 2014).

With regard to the objective of this thesis, the IO analysis is basically similar to the shift-share analysis in terms of the concept to decompose the industrial structure among regions (Rose and Casler, 1996). The shift-share analysis can decompose the various types of data with the basic approach extended, while the IO analysis can't help depending on the IO tables so that it is not easy to apply in the panel data except the IO table. For this reason, the IO analysis is not appropriate to this study as the second methodology which should be connected with the shift-share analysis.

A.3.3 Selection of methodology

Each methodology has weaknesses as well as strengths which are raised in previous studies, as shown in Table A-7. The advantages and disadvantages are as mentioned in the previous sub-section.

On the one hand, the family of IO analysis have some strengths, compared with econometric analysis. First of all, there is a huge body of port studies that apply IO analysis (Mulligan, 1994). In addition, they are very strong at analysing the gross economic impacts of port industries (Chang, 1978), which are categorised into three groups (i.e. direct activities, indirect ones, and induced ones), and the inter-industrial relations (García and López, 2004). However, they encounter some criticisms: port activities are not classified as a single category in SIC (Davis, 1983), arbitrary classification of port-related activities (Dooms et al., 2015), due to port activities being related with various small industries. Furthermore, they have a critical handicap in that they do not reflect the influence of the technological changes in transportation because they depend on the multiplier effects (Waters, 1977).

- No allowance for households purchasers' marginal responses to change: so that real budget shares remain unchanged with changes in household income and relative prices.
- Absence of budget constraints: so that changes in household or government consumption occur without reducing demand elsewhere.

Table A-7 Comparative assessment among three methodologies

Methodology	Strengths	Weaknesses
Shift-share Analysis	- Simple and easy with light data - Analyse the changes over time in with respect to magnitude and ratio - Implement strong comparative analyses both by the sector and by the region	- Descriptive - Little theoretic basement - Not supply any statistical results
Social Savings	- focusing on the benefits to users and social welfare (Crafts, 2004) - quite useful to evaluate the technological improvements in open economy situations (Crafts, 2004) - is not needed to measure output in the sector which uses the new technology (Leunig, 2010)	- Implicit assumption that relationship between price and marginal cost continues to be same even after the appearance of a new technology (McClelland, 1968) - Focusing on measuring only the gain to direct beneficiaries (David, 1969) - Not supply any information about the changing structure (Williamson, 2008) - Applied mainly in a specific research area (Leunig, 2010)
Input-Output Analysis	- The most frequently used tool in port studies (Artal-Tur et al., 2015) - Understand the whole economic impacts in a specific time (Chang, 1978) - Show the inter-industrial relations (García and López, 2004)	- Port activities are not grouped in a single category in SIC category (Davis, 1983) - Not consider technological changes in the transport system (Waters, 1977) - Arbitrary classification of direct, indirect and induced industry (Dooms et al., 2015) - High cost for data acquisition (Shan et al., 2014)
Econometric Analysis	- No need of classification of port activities (Shan et al., 2014) - Evaluate ‘*ceteris paribus*’ effects (Wooldridge, 2012) - Supply the statistical information of changes over time (Wooldridge, 2012) - Investigate the subjective matter with publicly available data (Shan et al., 2014)	- Need time-series data in detail, a set of quality panel data for comparative study among ports or regions (Bottasso et al., 2013) - The appropriateness of the proxy applied instead of a specific variable (Krugman, 2013)

On the other hand, the family of econometric analysis, whether they are based on the economic theory or not, have powerful strengths to analyse the changes over time: specifically, to evaluate ‘*ceteris paribus*’ effects with the statistical information of changes over time (Wooldridge, 2015). Furthermore, they support researchers to investigate the subjective matter with publicly available data (Shan et al., 2014) via adjusting independent variables and to escape any kinds of debates in terms of arbitrary classification of port activities (Shan et al., 2014). On the other hand, they also have some weaknesses in terms of the technical points of the empirical study. It needs time-series data in detail, especially, a set of quality panel data for comparative study among ports or regions (Bottasso et al., 2013).

With regard to this study, the econometric analysis; which is based on the economic growth model with production function applied, may be much more suitable than social savings and the IO analysis. First of all, econometric analysis has such a powerful strength to the point that the objective of this study is to analyse the changes of economic impacts of ports on their regions over time. Secondly, it is another better methodology in the aspect that this study intends to apply the methodology which can implement the objectives above without any kinds of arbitrary definition or classification of port activities. Lastly, it has the prevailing strength in the point to connect the shift-share analysis statistically and compare the results from econometric analysis and shift-share analysis respectively.

Appendix 4 Shift-share Analysis

A.4.1 Busan

Figure A-11 GVA per worker in Busan regional economy

(Unit: thousand KRW)

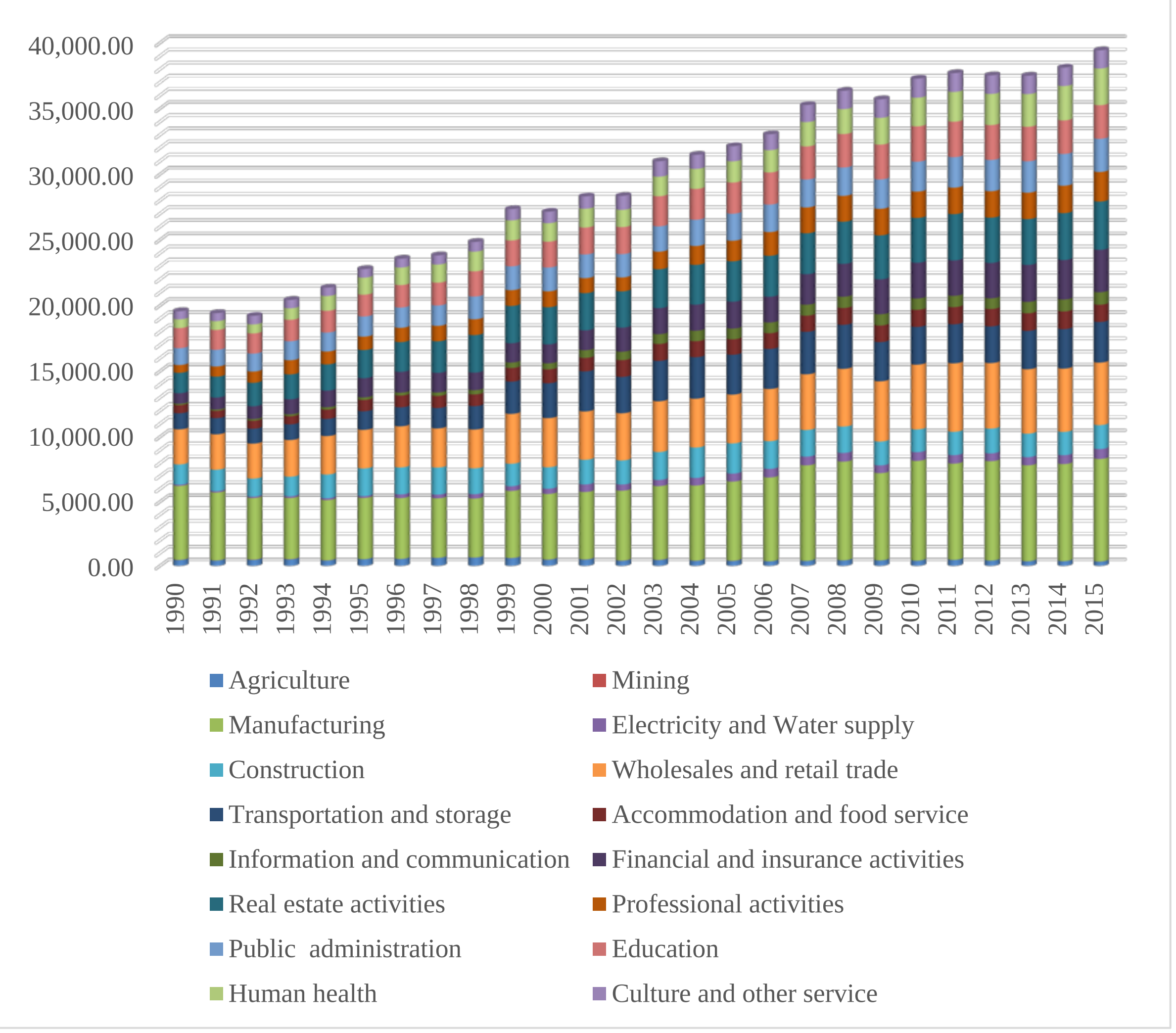


Figure A-12 Growth rate of GVA per worker in Busan regional economy

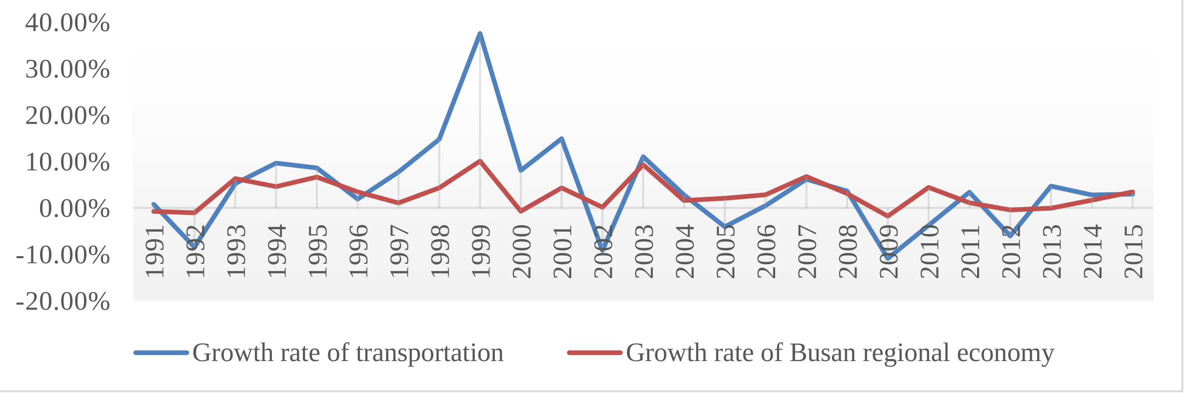


Figure A-13 GVA per worker in transportation in Busan

(Unit: thousand KRW)

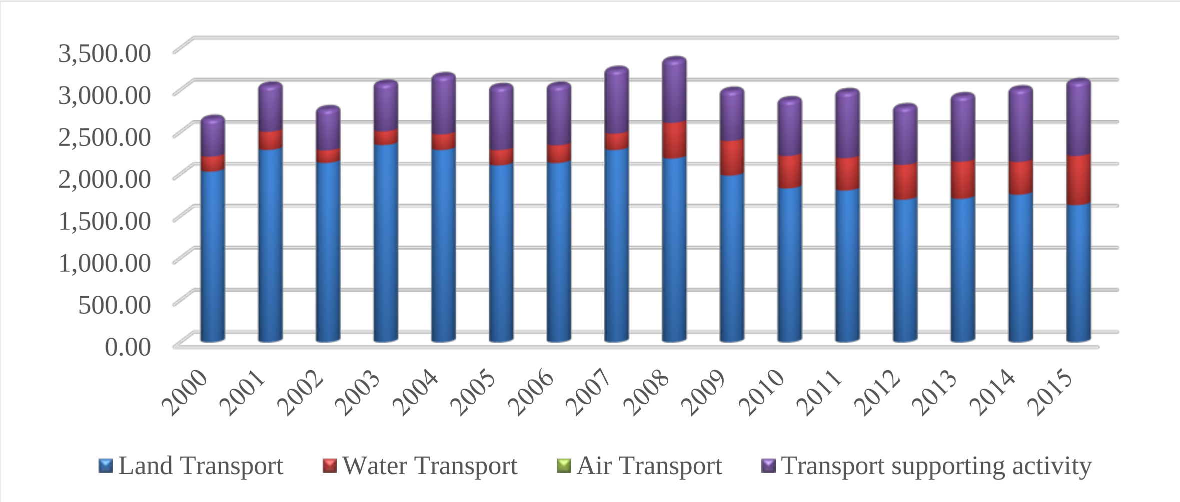


Figure A-14 GVA per worker of four sub-sectors in transportation in Busan

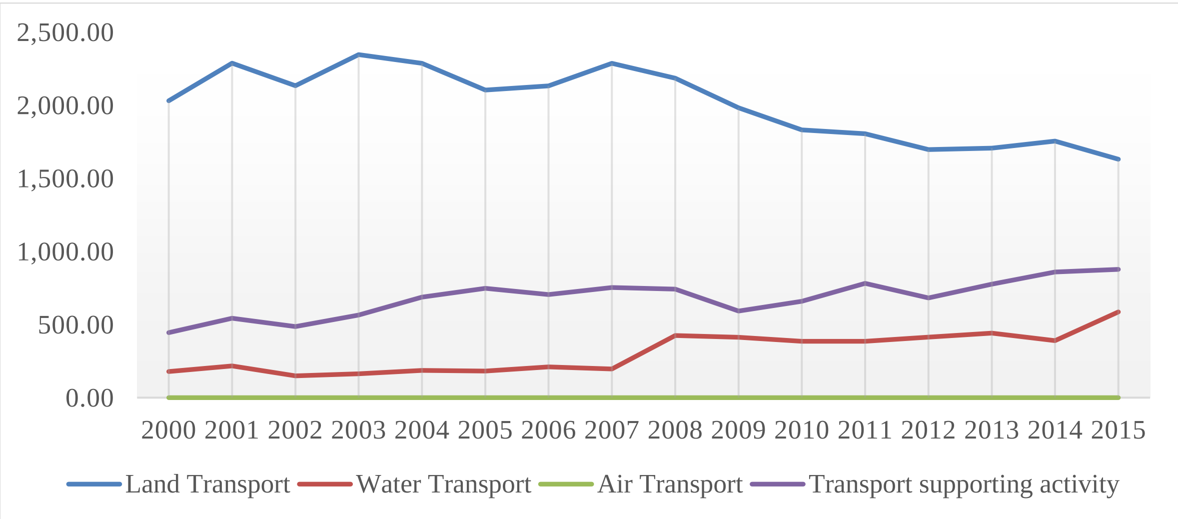


Figure A-15 Growth rate of GVA per worker of four sub-sectors in transportation in Busan

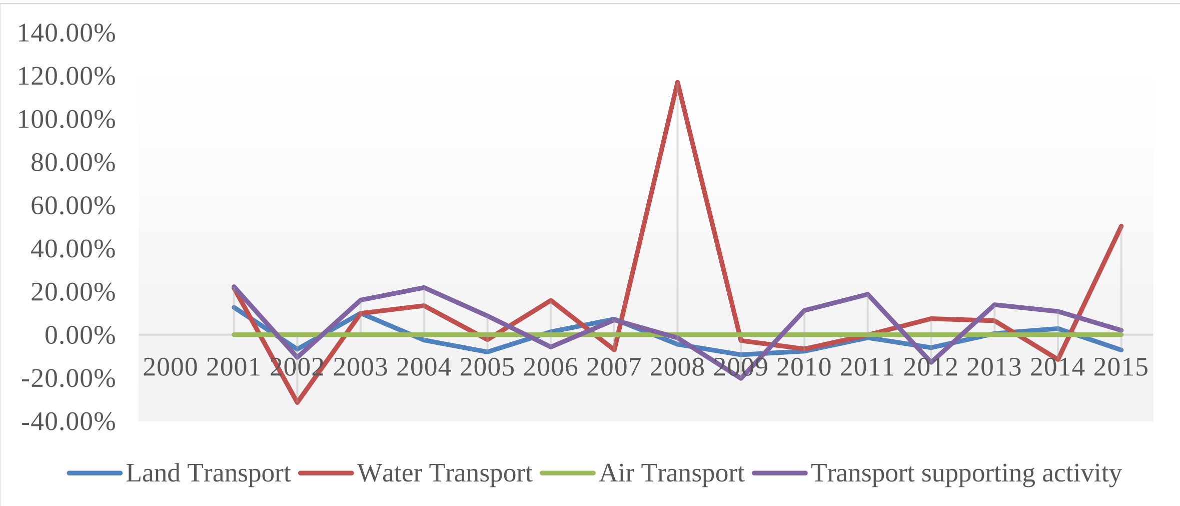
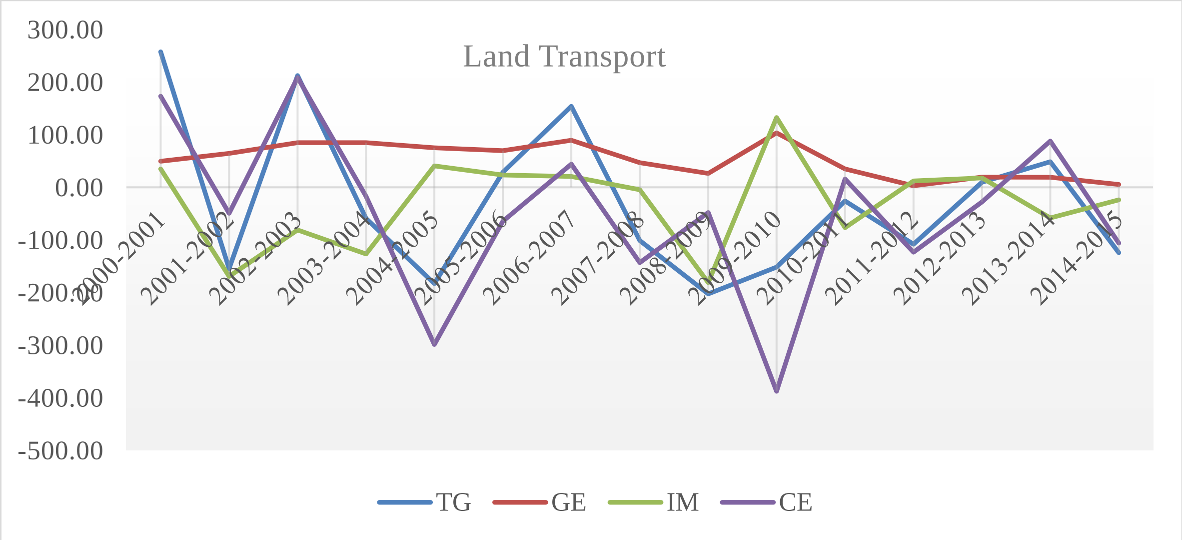
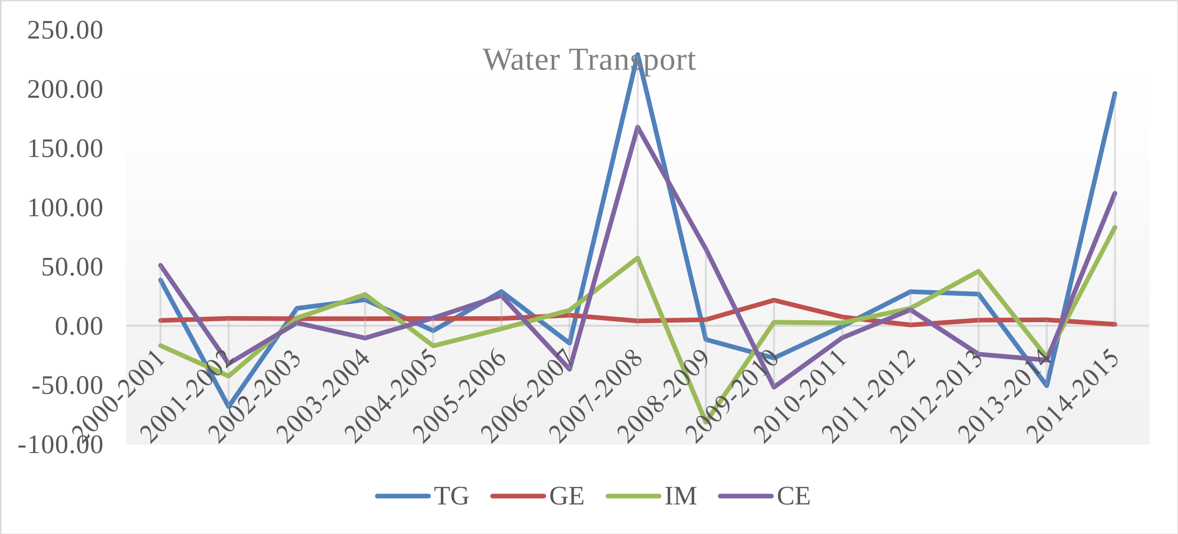
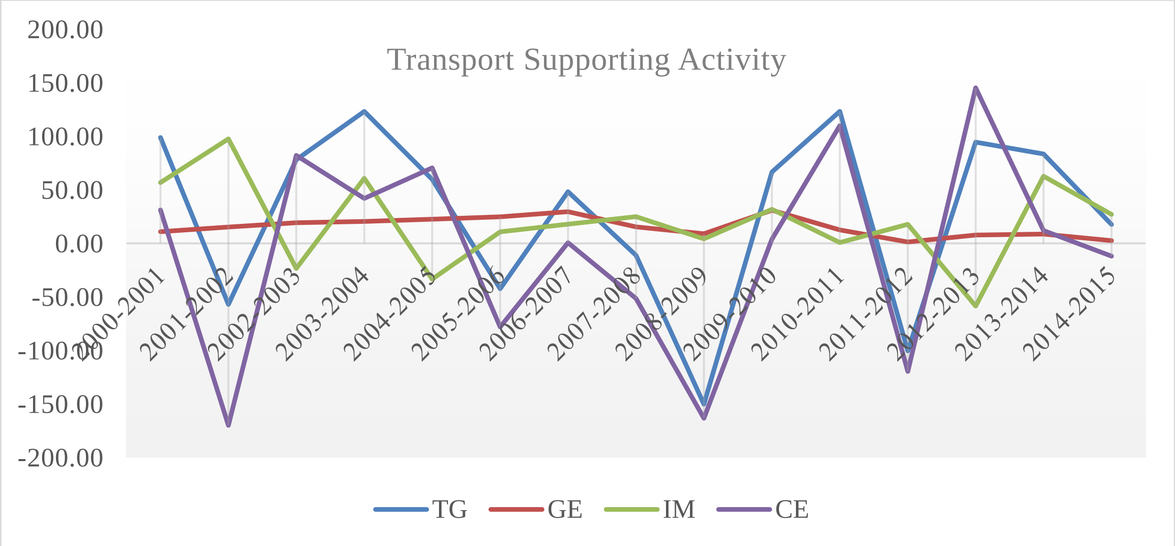


Figure A-16 Shift-share analysis of GVA per worker of sub-sectors in transportation in Busan

(Unit: thousand KRW)







A.4.2 Incheon

Figure A-17 GVA per worker in Incheon regional economy

(Unit: thousand KRW)

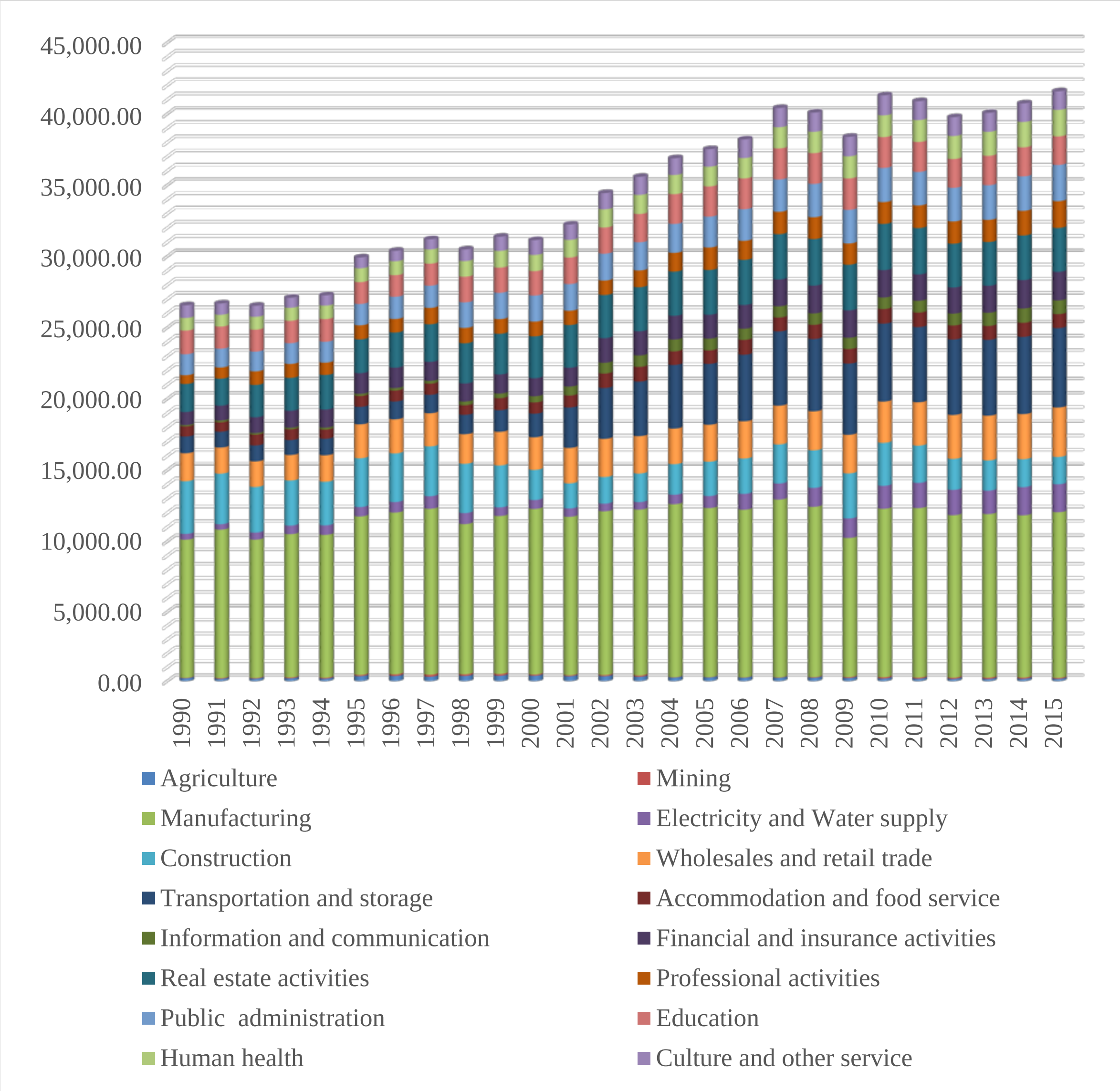


Figure A-18 Growth rate of GVA per worker in Incheon regional economy

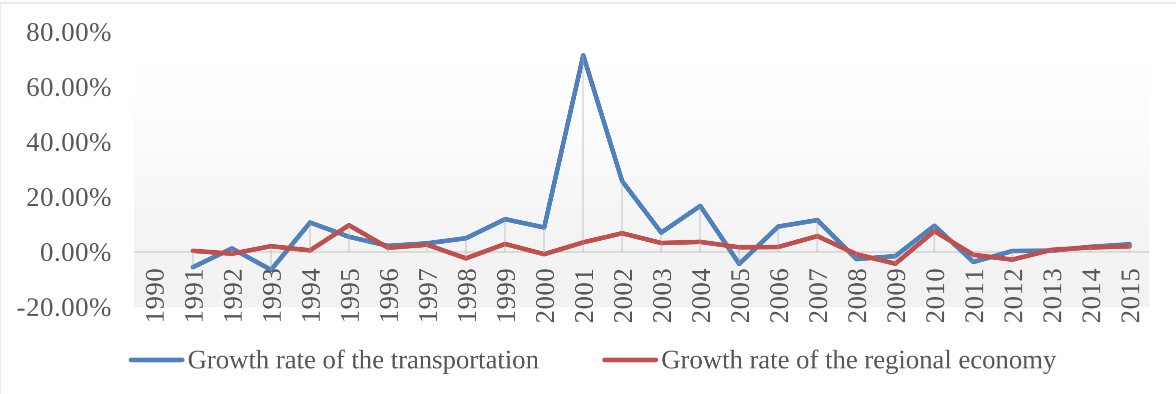
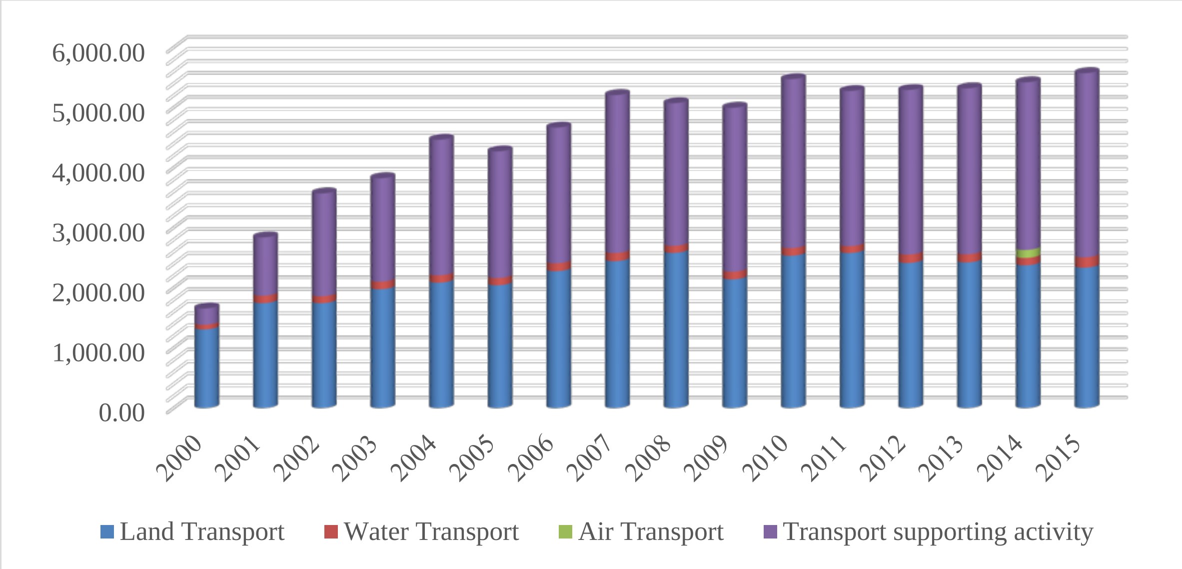
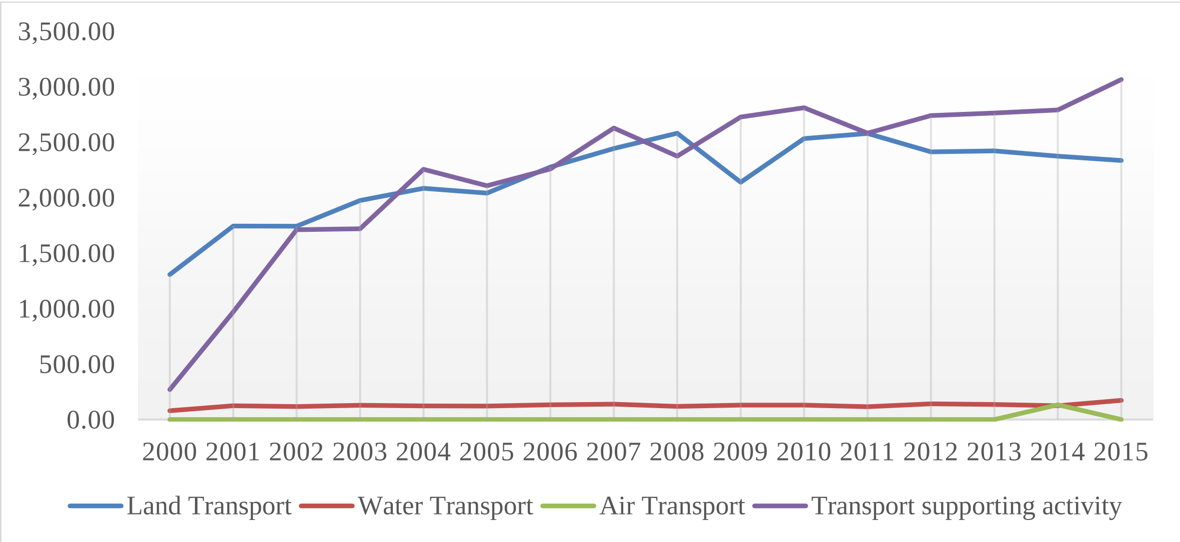


Figure A-19 GVA per worker of four sub-sectors in transportation in Incheon

(Unit: thousand KRW)





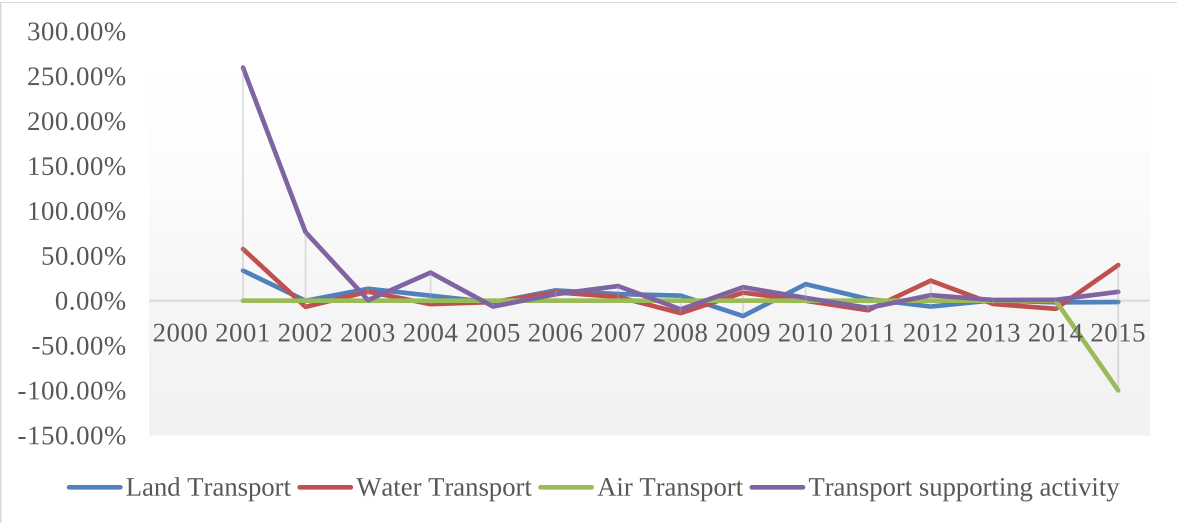
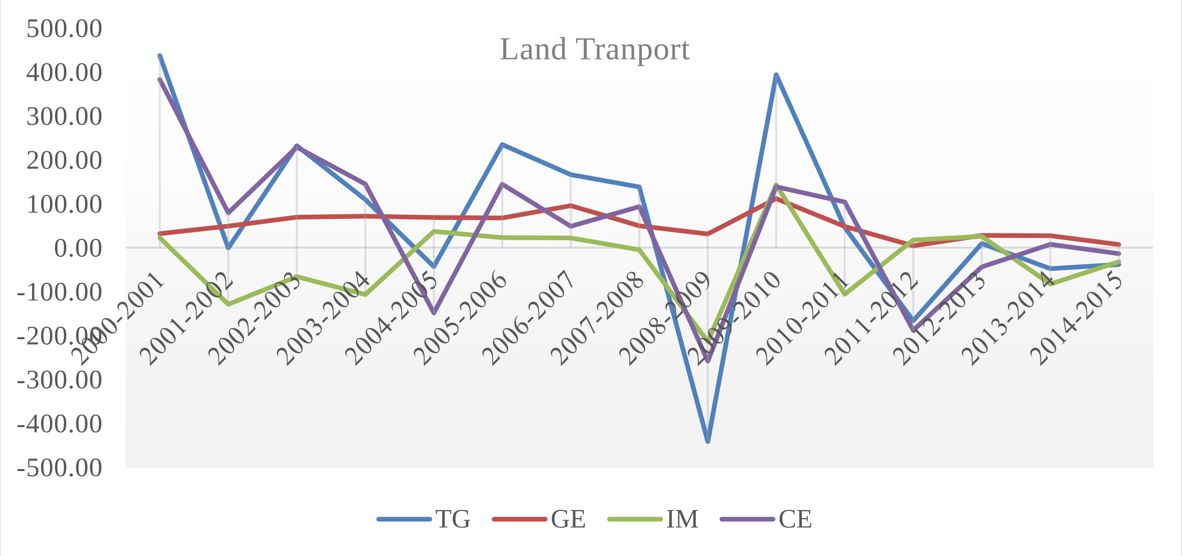
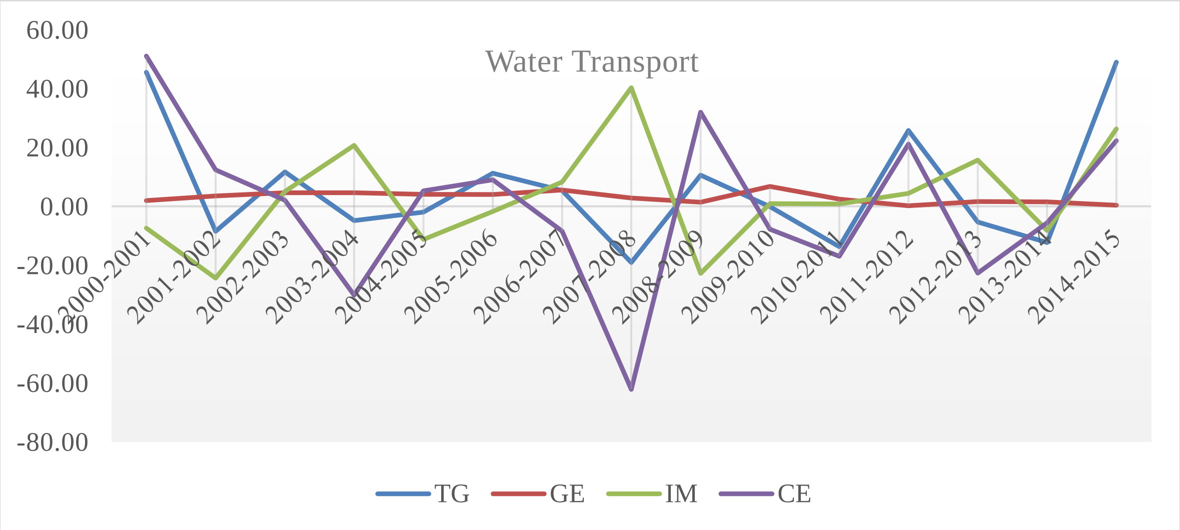
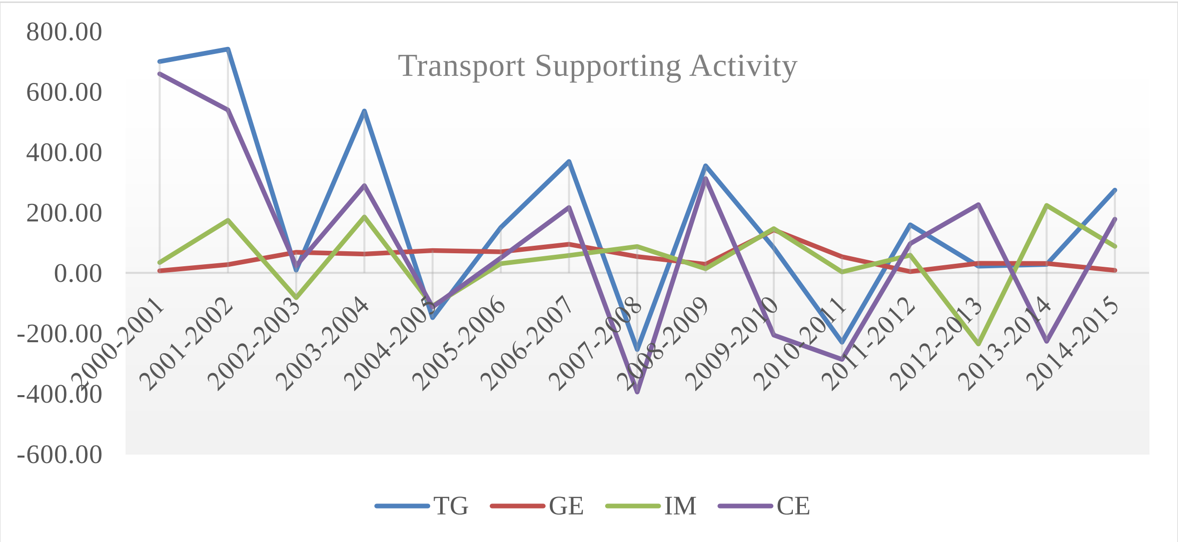


Figure A-20 Shift-share analysis of GVA per worker of sub-sectors in transportation in Incheon

(Unit: thousand KRW)







A.4.3 Ulsan

Figure A-21 GVA per worker in Ulsan regional economy

(Unit: thousand KRW)

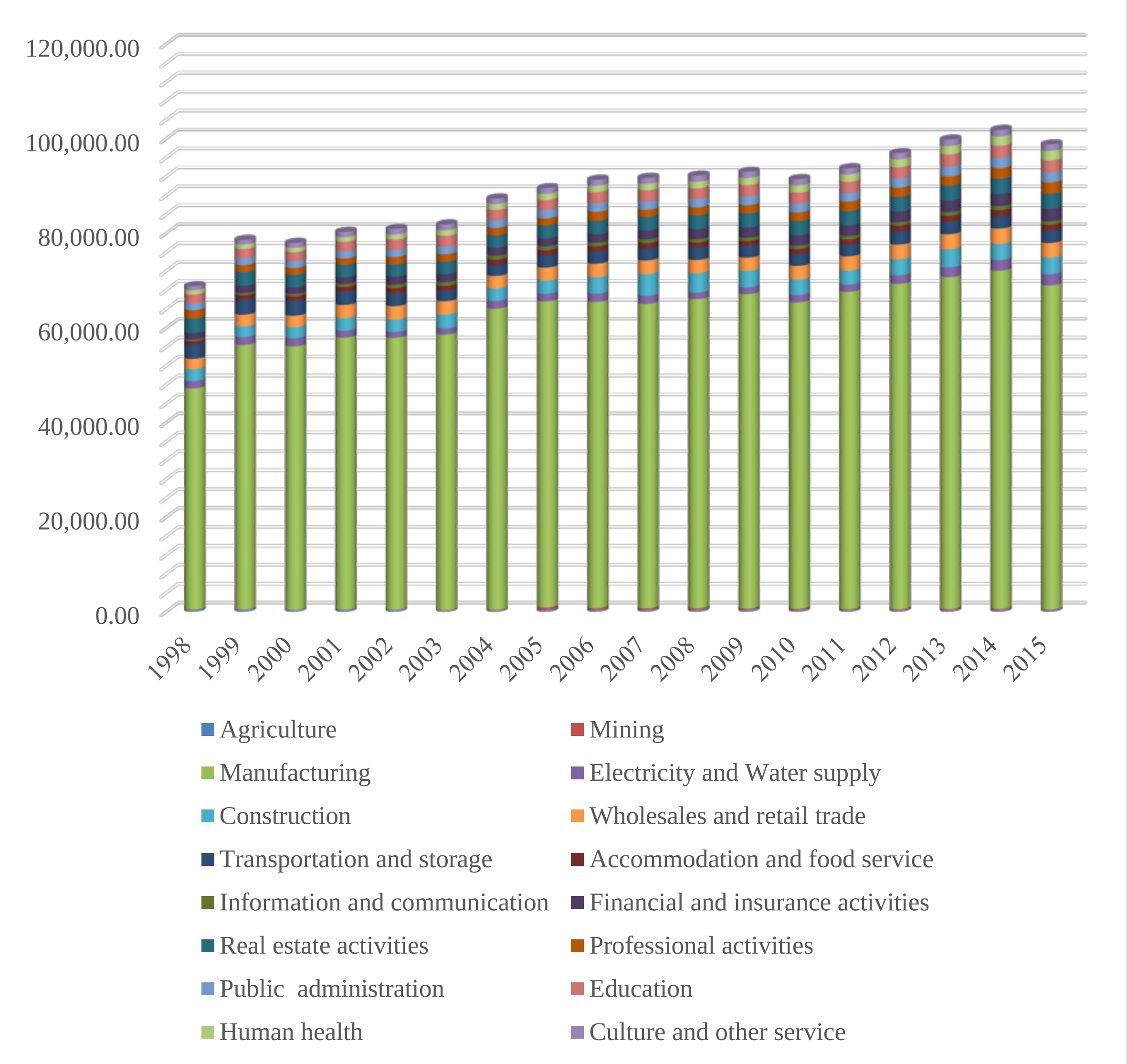
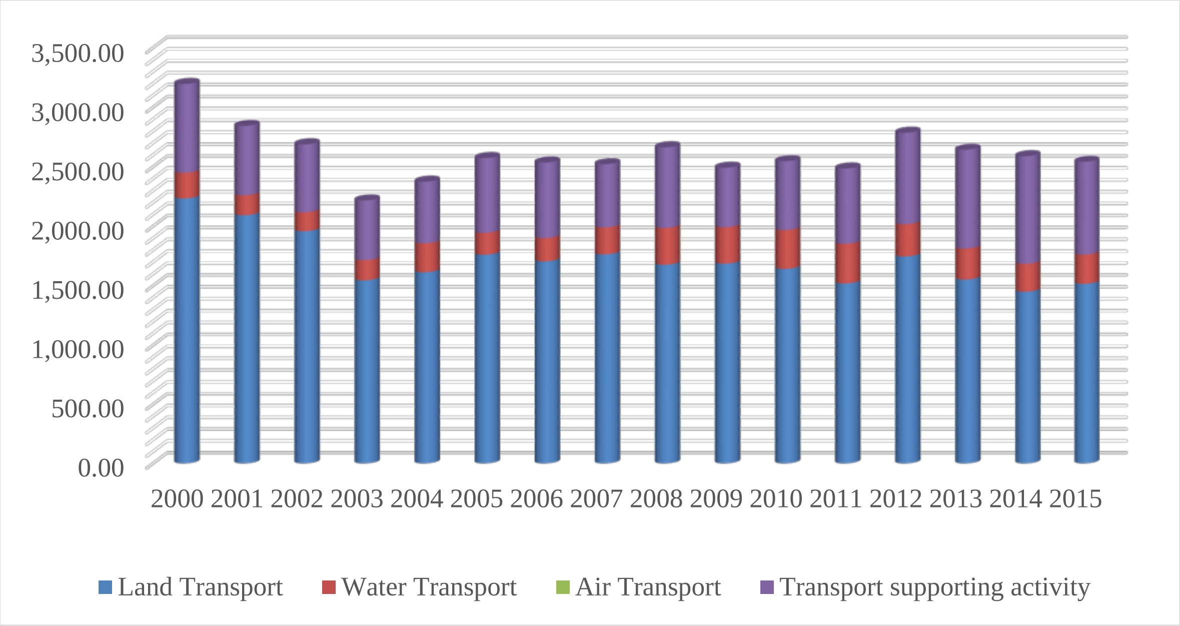
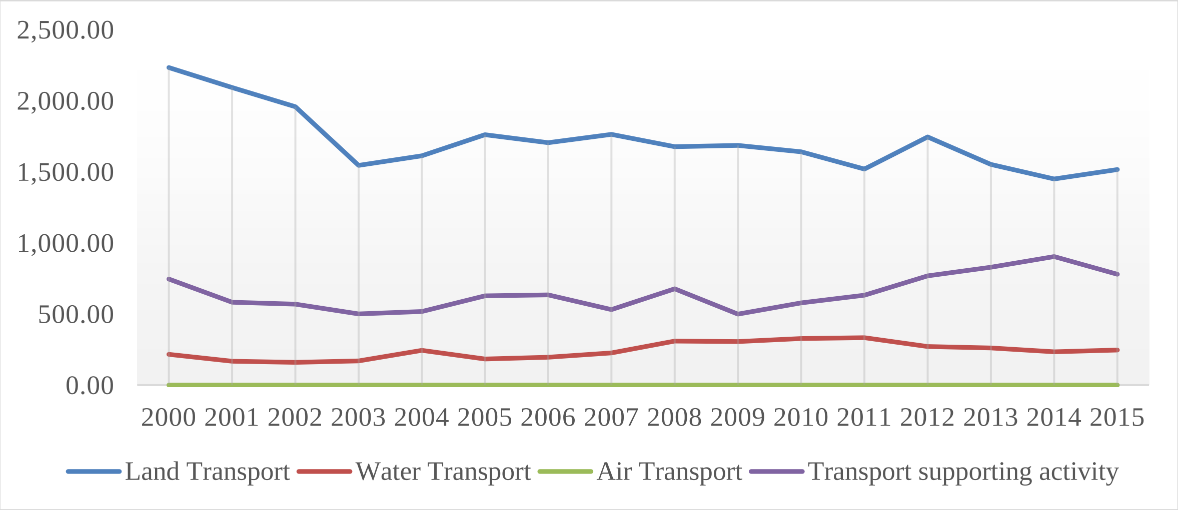


Figure A-22 Growth rate of GVA per worker in Ulsan regional economy

Figure A-23 GVA per worker of four sub-sectors in transportation in Ulsan

(Unit: thousand KRW)





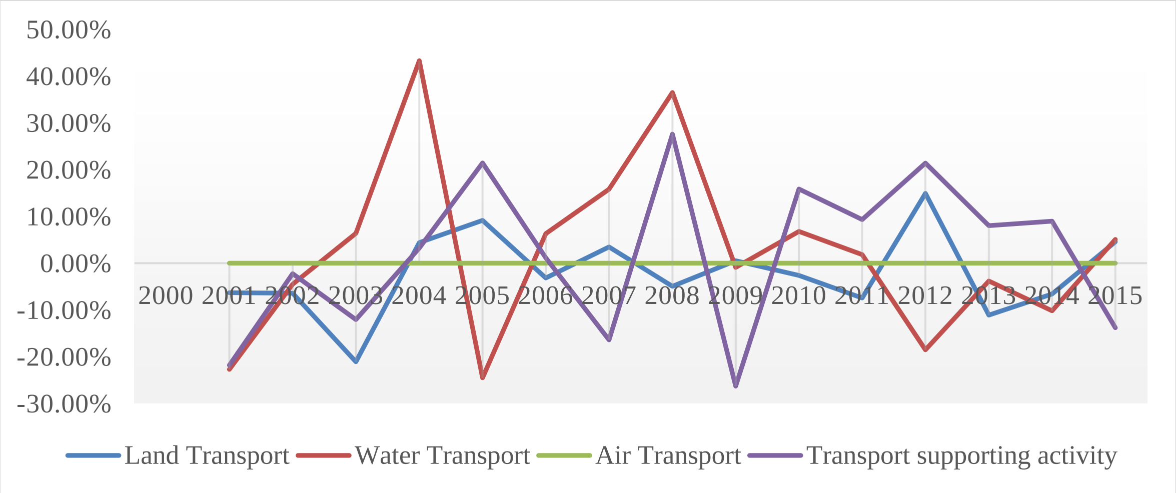
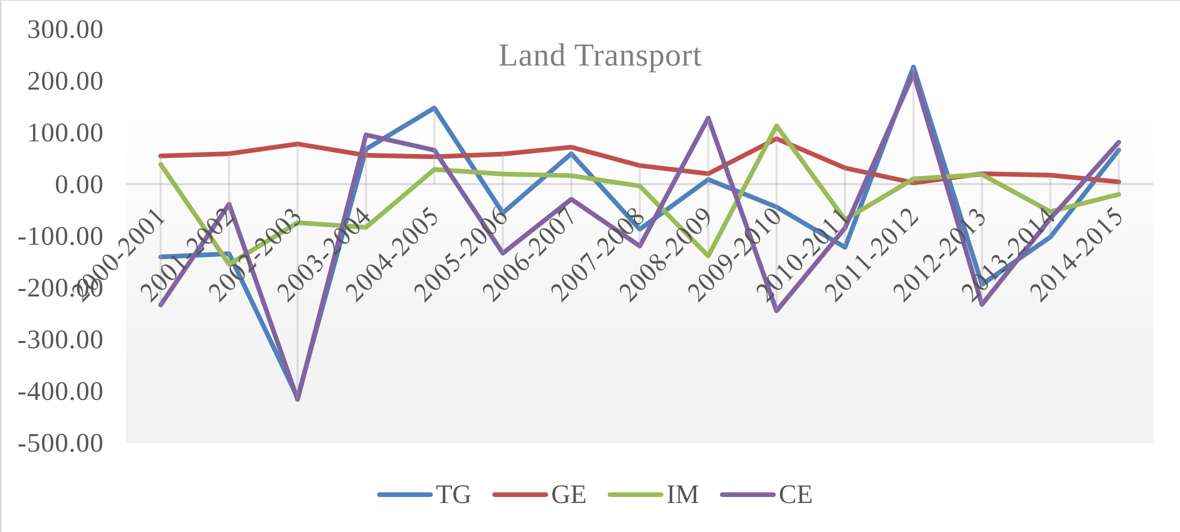
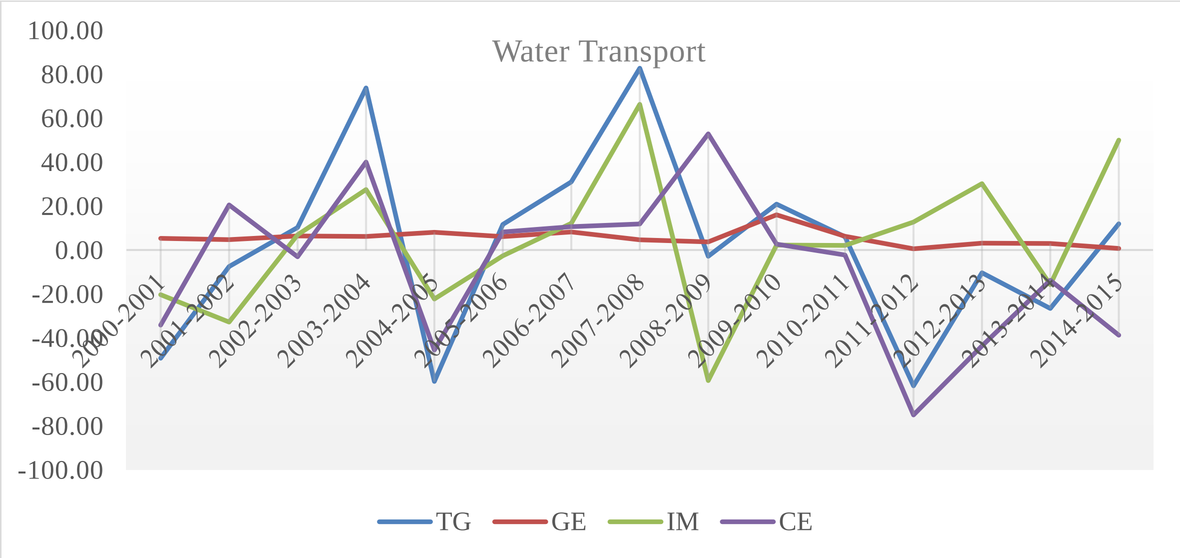
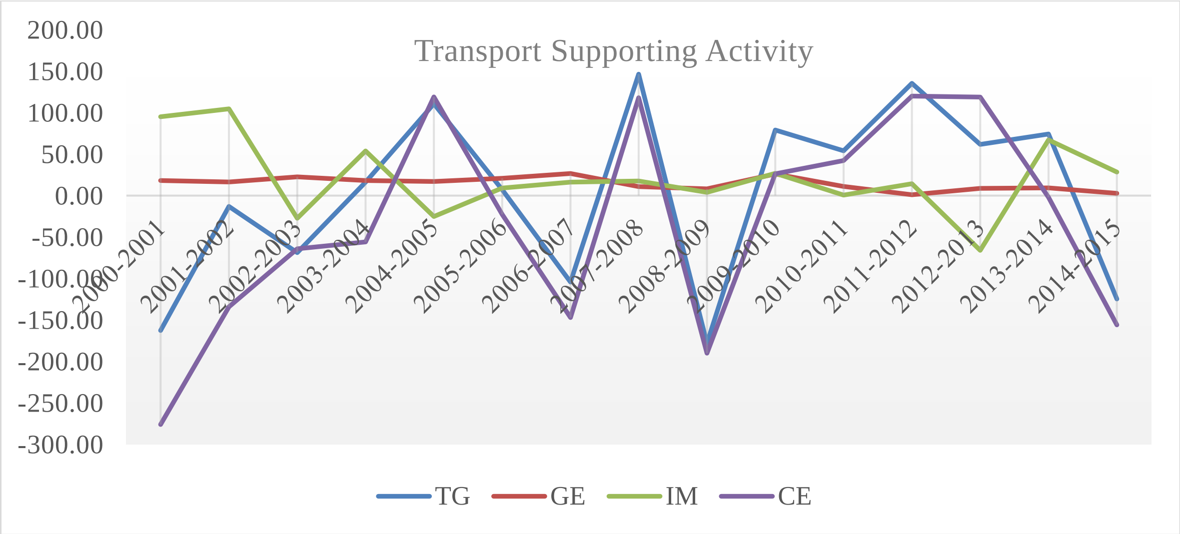


Figure A-24 Shift-share analysis of GVA per worker of sub-sectors in transportation in Ulsan

(Unit: thousand KRW)







A.4.4 Jeonnam

Figure A-25 GVA per worker in Jeonnam regional economy

(Unit: thousand KRW)

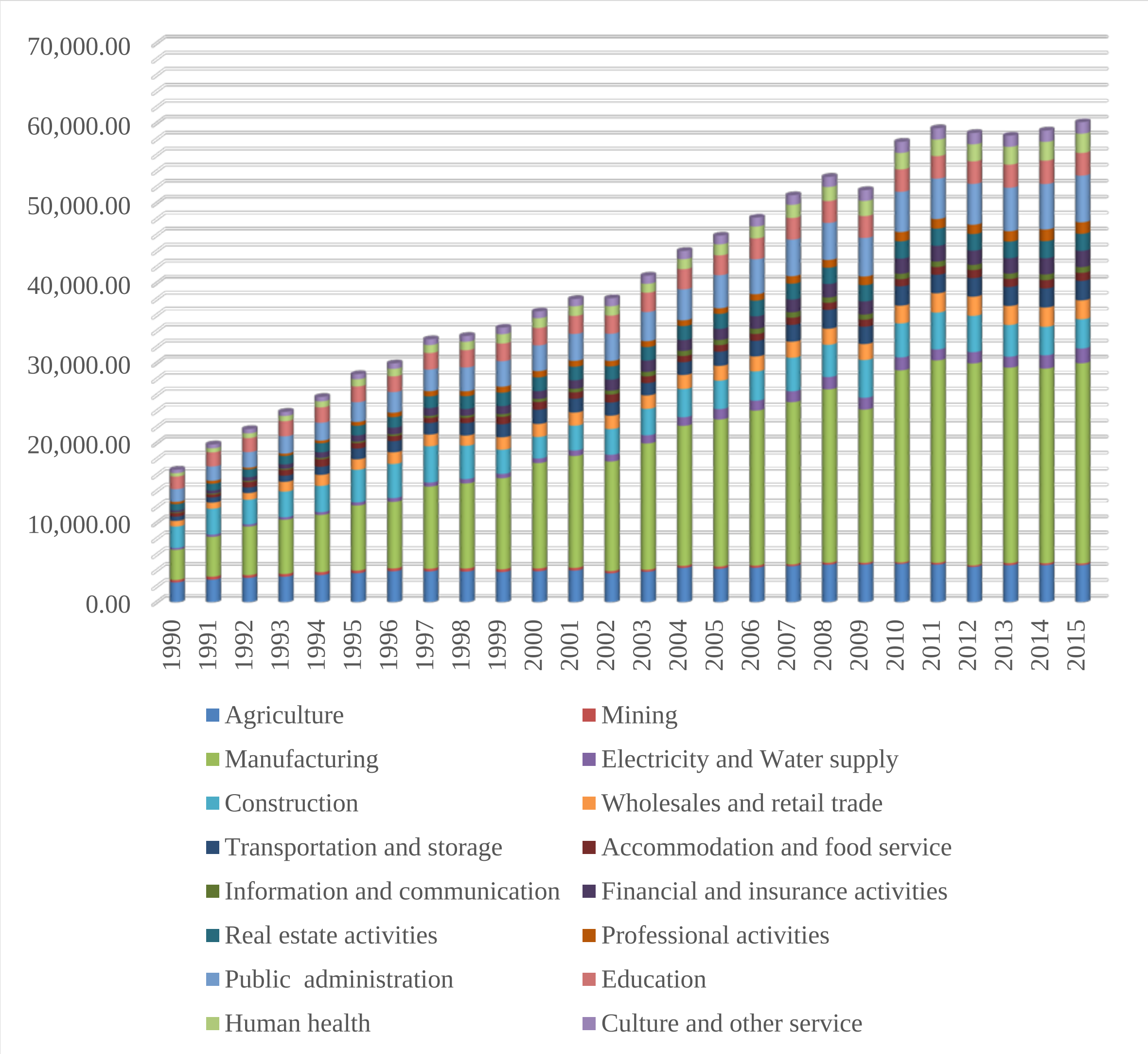


Figure A-26 Growth rate of GVA per worker in Jeonnam regional economy

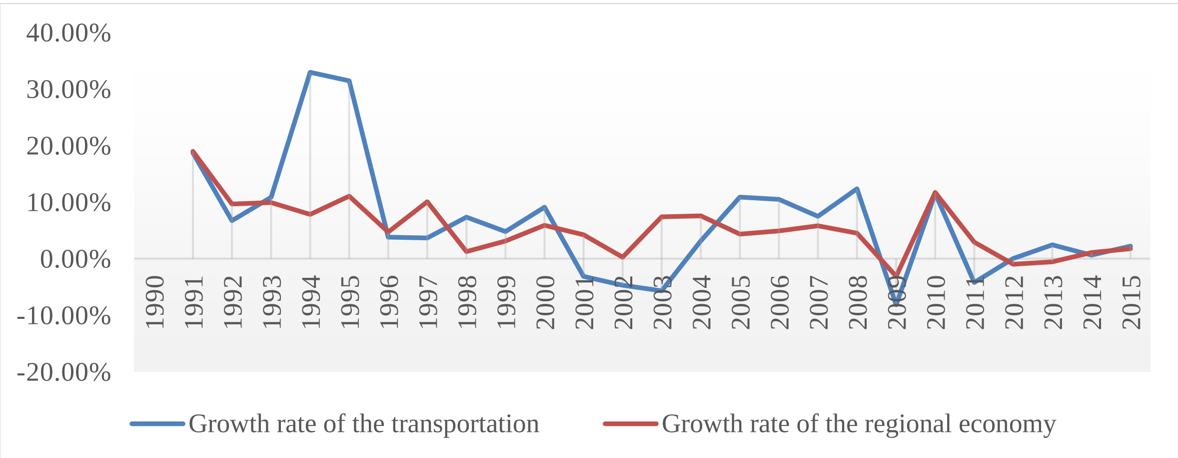
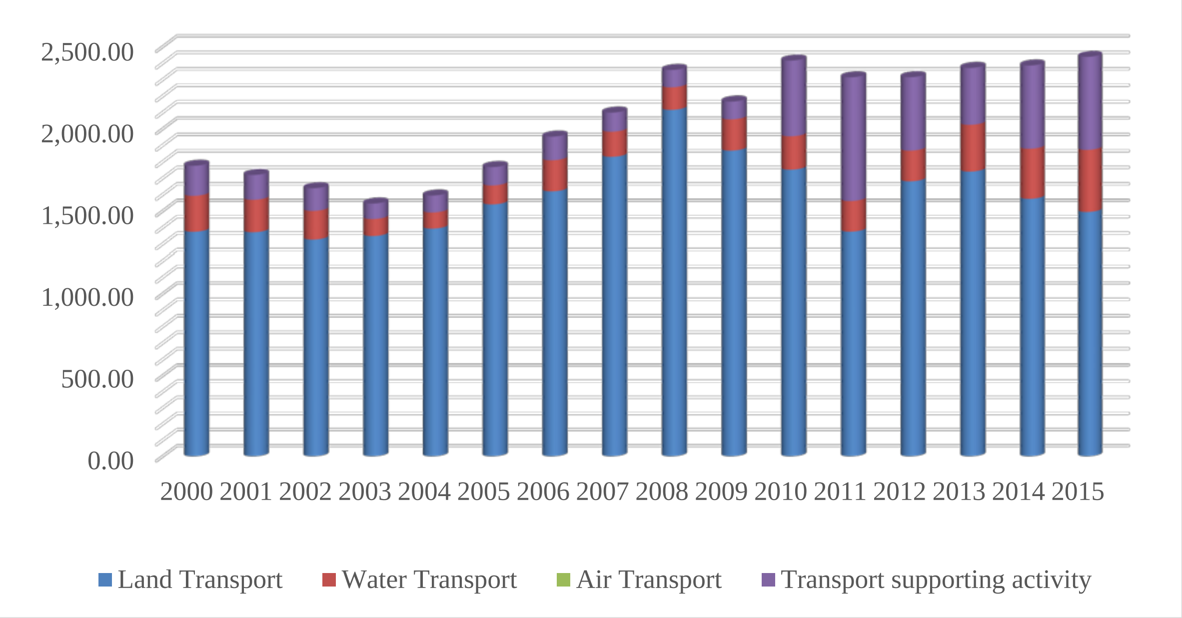
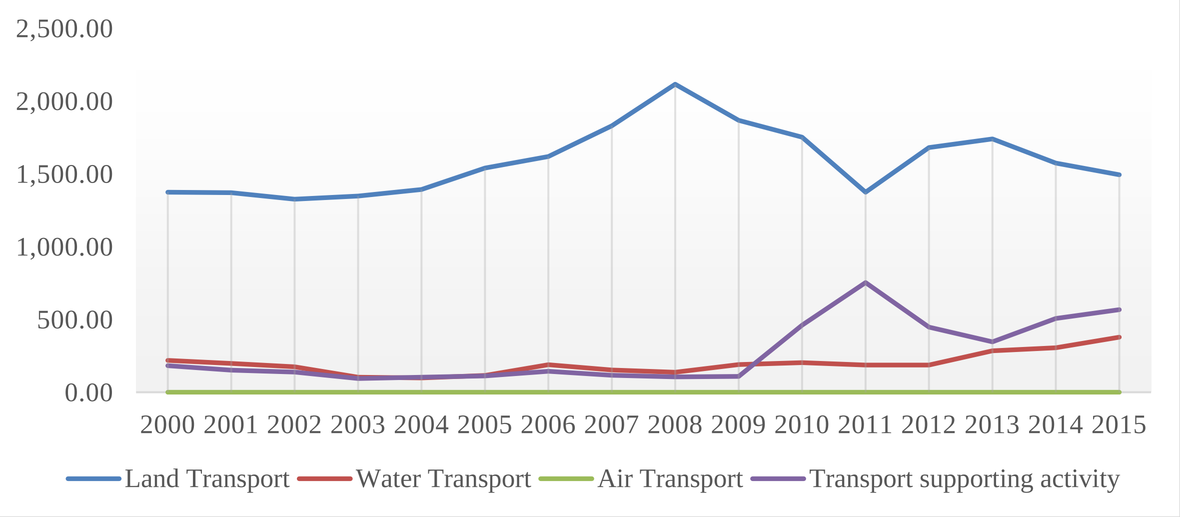


Figure A-27 GVA per worker of 4 sub-sections in transportation in Jeonnam

(Unit: thousand KRW)





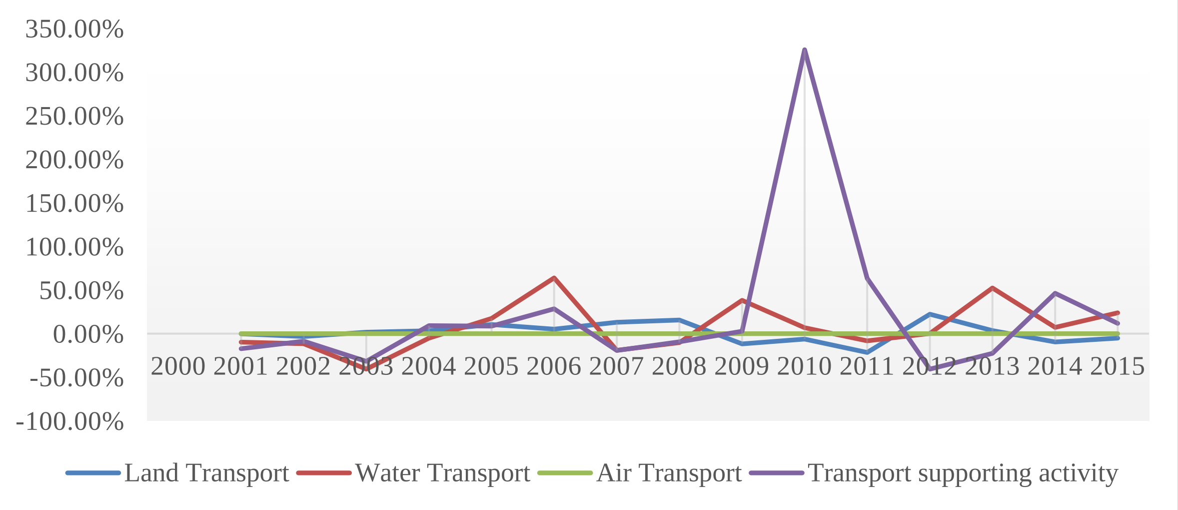
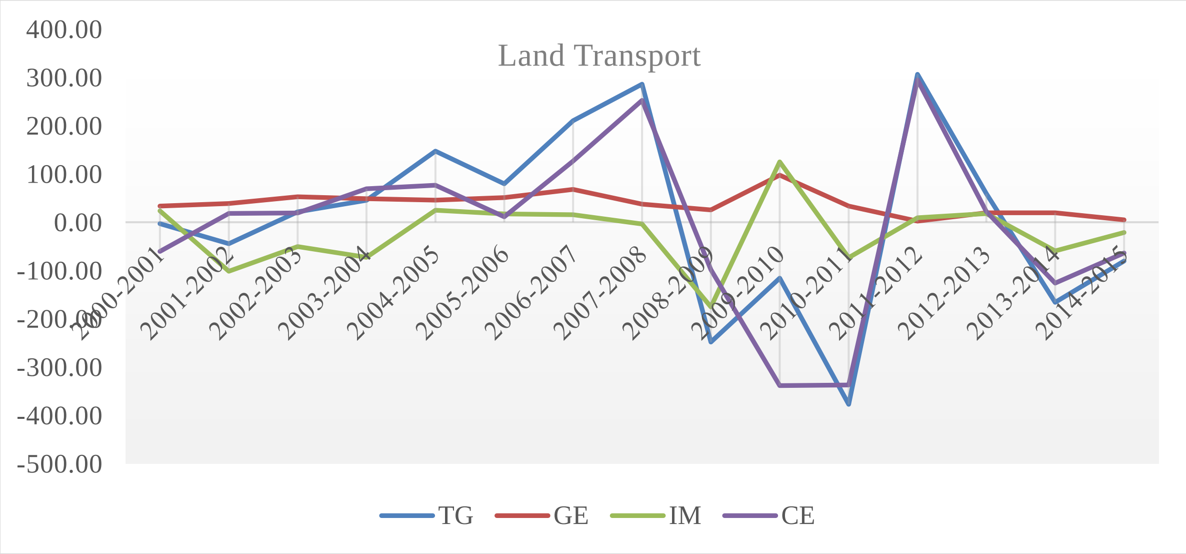
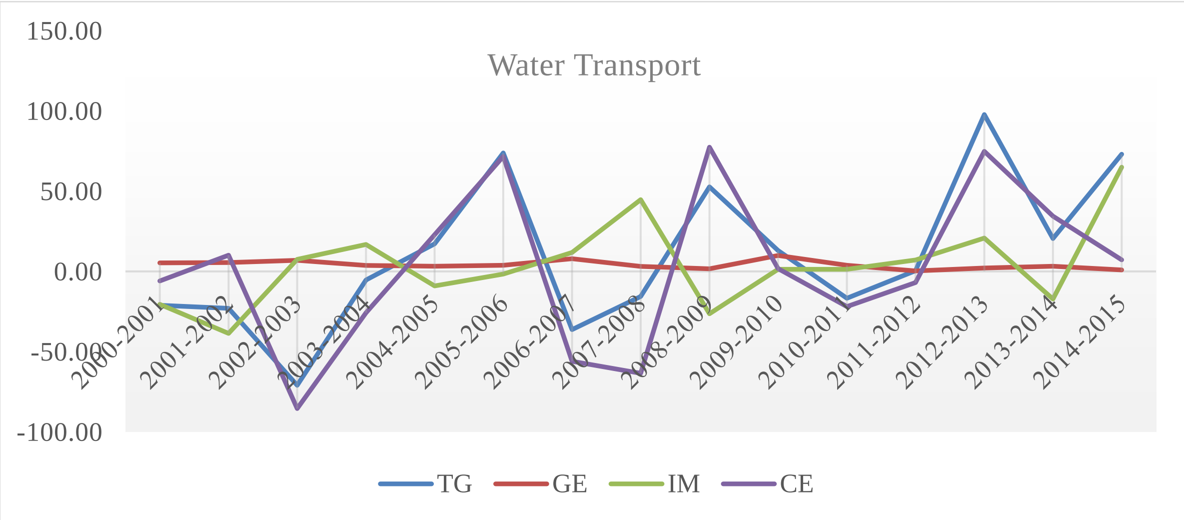
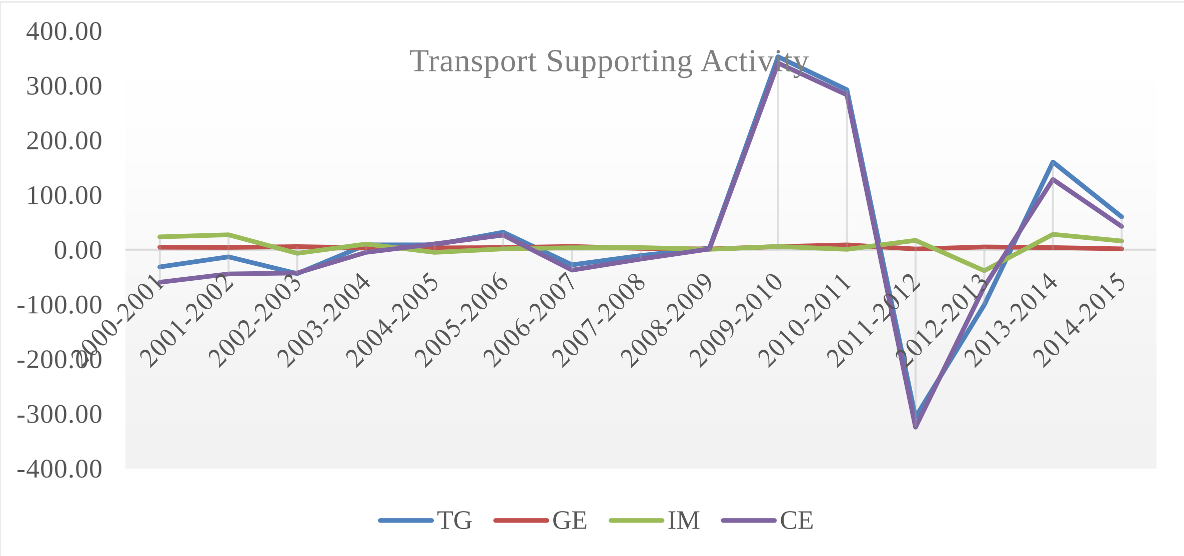


Figure A-28 Shift-share analysis of GVA per worker of sub-sections in transportation in Jeonnam

(Unit: thousand KRW)







Appendix 5 Econometric Anaysis

A.5.1 Descriptive analysis

i) Seoul

```
. bysort ID: summarize y yt ng Sk Sh rd RT TEUp TEUr
```

-> ID = 1

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	43582.08	9818.484	25982.6	57814.64
yt	26	1627.837	217.0701	1196.608	1966.376
ng	23	-.3265313	.6154664	-1.89256	1.068809
Sk	21	9.933678	.9572879	7.50821	11.12877
Sh	26	27.95325	7.222717	16.80052	39.78854
rd	25	15090.38	1726.811	12360.19	19518.88
RT	0				
TEUp	0				
TEUr	0				

ii) Busan

-> ID = 2

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	29566.76	6855.873	19221.04	39437.9
yt	26	2414.009	805.2692	1131.346	3351.433
ng	23	-.3821991	.4844964	-1.011008	1.196132
Sk	21	13.9655	1.80552	9.153353	16.85345
Sh	26	18.93146	6.37727	10.01267	29.49886
rd	25	16039.45	4371.147	7462.829	21031.96
RT	22	2.03e+08	8.94e+07	8.17e+07	3.60e+08
TEUp	26	9617062	5556043	2348475	1.95e+07
TEUr	26	8660402	4325617	2348475	1.48e+07

iii) Daegu

-> ID = 3

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	26289.09	4473.627	19754.54	33818.22
yt	26	1148.77	91.58561	967.0904	1353.065
ng	23	.4285385	1.284298	-.5473716	5.857003
Sk	21	11.36558	1.229587	7.93086	13.09689
Sh	26	19.66794	5.433336	13.17627	30.90627
rd	25	20102.59	4086.459	11537.44	25429.68
RT	0				
TEUp	0				
TEUr	0				

iv) Incheon

-> ID = 4

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	34502.17	5409.312	26542.02	41595.63
yt	26	3275.406	1860.697	1048.615	5571.326
ng	23	1.584821	1.439627	-.2216337	7.004545
Sk	21	15.45961	2.130715	10.13223	19.78534
Sh	26	15.11635	4.448569	8.519004	23.03765
rd	25	17844.64	2304.849	13334.94	22374.69
RT	22	1.28e+08	1.82e+07	9.39e+07	1.58e+08
TEUp	26	1043787	774341	112472	2414562
TEUr	26	1043787	774341	112472	2414562

V) Gwangju

-> ID = 5

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	30654.65	5319.777	21605.48	37583.25
yt	26	1087.604	107.502	918.9629	1264.756
ng	23	.8608637	.6316979	-.1533898	2.094154
Sk	21	11.94771	1.519447	7.848088	13.91205
Sh	26	24.68527	7.341952	12.55411	34.83444
rd	25	23080.91	3976.622	18229.29	33843.73
RT	0				
TEUp	0				
TEUr	0				

vi) Daejeon

-> ID = 6

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	32306.37	3524.316	26836.9	37535.33
yt	26	1058.709	123.9459	867.6745	1330.964
ng	23	1.333054	1.220469	-.7991182	4.900088
Sk	21	18.41024	1.570399	15.66903	21.82029
Sh	26	25.48817	7.920378	11.13801	37.39021
rd	25	25670.66	2002.114	18684.6	28948.47
RT	0				
TEUp	0				
TEUr	0				

vii) Ulsan

-> ID = 7

Variable	Obs	Mean	Std. Dev.	Min	Max
y	18	88652.87	8872.457	68806.72	101830.6
yt	18	2665.473	268.838	2216.653	3231.911
ng	18	.8907477	.341019	.2298561	1.6125
Sk	18	18.21933	2.296999	13.59701	21.20157
Sh	18	17.69148	3.916226	12.60331	24.91525
rd	18	28657.55	2280.205	22835.1	34389.11
RT	22	1.61e+08	2.36e+07	1.05e+08	1.97e+08
TEUp	26	225724.2	148391.4	80	400581
TEUr	26	225724.2	148391.4	80	400581

viii) Gyeongg

-> ID = 8

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	34492.79	7727.535	22153.93	47251.32
yt	26	912.5229	354.8257	403.5115	1451.502
ng	23	2.875042	1.492249	1.055395	5.988615
Sk	21	18.8018	2.573329	15.01345	24.89111
Sh	26	20.75215	7.551954	7.767355	31.73005
rd	25	21566.3	2260.275	15890.75	27747.98
RT	22	5.40e+07	3.22e+07	1.91e+07	1.17e+08
TEUp	16	318409.8	194427.7	988	565729
TEUr	16	318409.8	194427.7	988	565729

ix) Gangwon

-> ID = 9

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	34385.37	6839.236	23482.45	44366.7
yt	26	1366.684	251.7608	1092.634	1790.246
ng	23	.0374385	.5505369	-.915251	1.174339
Sk	21	12.7644	1.706113	9.175422	15.96287
Sh	26	14.40793	5.767373	5.709877	23.73114
rd	25	69268.7	16157.93	39489.47	102090.3
RT	22	3.71e+07	6205912	2.82e+07	5.09e+07
TEUp	17	4920.412	3004.026	32	11901
TEUr	17	4920.412	3004.026	32	11901

x) Chungbuk

-> ID = 10

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	38562.01	10690.28	20589.23	55062.83
yt	26	1136.469	287.8782	705.5812	1624.514
ng	23	.577235	.4661334	-.2173797	1.490733
Sk	21	18.70147	2.641378	13.03706	23.82201
Sh	26	14.38299	4.880347	7.154213	21.6
rd	25	52871.45	10325.67	33359.64	71335.3
RT	22	0	0	0	0
TEUp	0				
TEUr	0				

xi) Chungnam

-> ID = 11

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	49579.33	21304.19	18202.25	80104.8
yt	26	1330.914	500.4661	421.5304	2206.815
ng	23	.5137008	1.133128	-3.424536	2.194351
Sk	21	22.44928	3.727465	14.40692	30.80503
Sh	26	12.48526	5.928605	4.767442	22.94686
rd	25	43937.83	10103.21	24251.02	56595.03
RT	22	7.05e+07	2.42e+07	2.12e+07	1.05e+08
TEUp	9	51028.33	32019.48	8388	104636
TEUr	9	51028.33	32019.48	8388	104636

xii) Jeonbuk

-> ID = 12

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	31753.81	8171.741	16623.07	42351.81
yt	26	931.7158	227.8065	530.3017	1289.791
ng	23	-.2990133	.8136119	-2.592074	.8051241
Sk	21	12.31664	2.026907	7.939997	15.47439
Sh	26	16.12851	5.642834	7.380074	26.26263
rd	25	49262.5	12163.46	30097.67	71219.16
RT	22	1.50e+07	3874353	7339667	1.98e+07
TEUp	18	45596.5	32383.03	3638	122385
TEUr	18	45596.5	32383.03	3638	122385

xiii) Jeonnam

-> ID = 13

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	41090.17	13840.72	16668.18	60123.09
yt	26	1688.393	590.8832	547.6918	2438.259
ng	23	-.7244276	.7461655	-2.093878	.4198567
Sk	21	18.36915	3.834929	13.00281	27.13818
Sh	26	10.03261	4.375763	4.471195	16.81864
rd	25	56217.71	17757.41	25714.73	92456.55
RT	22	1.94e+08	5.52e+07	1.14e+08	2.98e+08
TEUp	21	1394795	877240.6	11826	2492900
TEUr	21	1394795	877240.6	11826	2492900

xiv) Gyeongbuk

-> ID = 14

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	40413.17	13664.55	18643.5	58500.63
yt	26	1052.299	336.0528	500.0607	1594.821
ng	23	-.2111879	.8779282	-3.535103	.7993443
Sk	21	23.54658	5.890979	17.95159	37.43493
Sh	26	10.56071	4.322207	4.261796	18.94452
rd	25	45938.28	11560.6	27538.05	64989.94
RT	22	5.52e+07	8232513	3.77e+07	6.77e+07
TEUp	14	49250.43	61137.9	0	143480
TEUr	14	49250.43	61137.9	0	143480

xv) Gyeongnam

-> ID = 15

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	39845.19	9525.087	21507.47	52235.55
yt	26	1192.521	286.4366	532.347	1527.566
ng	23	-.3781931	5.178889	-24.04578	1.587673
Sk	21	15.38112	1.366737	11.49007	17.10828
Sh	26	15.5007	5.274563	6.72956	24.2497
rd	25	43281	9792.815	27089.55	62930.11
RT	22	3.96e+07	1.37e+07	1.90e+07	6.33e+07
TEUp	26	23854.19	20416.99	253	65041
TEUr	26	980513.5	1698065	253	4717828

xvi) Jeju

-> ID = 16

Variable	Obs	Mean	Std. Dev.	Min	Max
y	26	28871.01	6367.216	16948.71	38507.31
yt	26	1368.933	413.7484	754.4812	2248.045
ng	23	.9763441	.6730201	.2288909	2.850659
Sk	21	9.535293	1.504668	6.023305	11.97745
Sh	26	15.60036	4.020476	8.75	22.98137
rd	25	71307.46	23076.28	43055.24	142772
RT	22	2989153	583016.1	2201140	4884884
TEUp	18	36054.78	25272.66	0	87614
TEUr	18	36054.78	25272.66	0	87614

A.5.2 Correlation Analysis

```
. corr lny L.lny yt lnng lnSk lnSh lnrd lnRT lnTEUp lnTEUr
(obs=121)
```

	lny	L. lny	yt	lnng	lnSk	lnSh	lnrd	lnRT	lnTEUp	lnTEUr
lny										
--.	1.0000									
L1.	0.9958	1.0000								
yt	0.2124	0.2149	1.0000							
lnng	-0.0609	-0.0672	0.1165	1.0000						
lnSk	0.6692	0.6583	0.2252	0.1853	1.0000					
lnSh	0.2371	0.2464	0.0780	0.1567	0.3335	1.0000				
lnrd	0.0157	0.0191	-0.3740	-0.4666	-0.3170	0.0221	1.0000			
lnRT	0.5509	0.5462	0.4392	0.1290	0.7433	0.0565	-0.6132	1.0000		
lnTEUp	0.1524	0.1502	0.5800	0.2607	0.3303	0.1052	-0.6662	0.5152	1.0000	
lnTEUr	0.2023	0.2070	0.4874	0.2124	0.3359	0.2152	-0.5517	0.5153	0.7810	1.0000

```
. corr lny L.lny yt lnng lnSk lnSh lnrd lnRT lnTEUp lnTEUr if Year>=1994 & Year<=2000
(obs=19)
```

	lny	L. lny	yt	lnng	lnSk	lnSh	lnrd	lnRT	lnTEUp	lnTEUr
lny										
--.	1.0000									
L1.	0.9814	1.0000								
yt	0.8941	0.8632	1.0000							
lnng	0.0526	0.0702	0.1630	1.0000						
lnSk	0.4612	0.4258	0.3917	0.4289	1.0000					
lnSh	0.1010	0.0992	-0.0518	0.1495	0.0641	1.0000				
lnrd	0.1013	0.1315	-0.1516	-0.6368	-0.4731	-0.0993	1.0000			
lnRT	0.4091	0.3864	0.5779	0.3885	0.6617	-0.3152	-0.6814	1.0000		
lnTEUp	0.0903	0.0853	0.3845	0.4159	0.3432	-0.2503	-0.7683	0.6793	1.0000	
lnTEUr	0.0903	0.0853	0.3845	0.4159	0.3432	-0.2503	-0.7683	0.6793	1.0000	1.0000

```
. corr lny L.lny yt lnng lnSk lnSh lnrd lnRT lnTEUp lnTEUr if Year>=2001 & Year<=2008
(obs=43)
```

	lny	L. lny	yt	lnng	lnSk	lnSh	lnrd	lnRT	lnTEUp	lnTEUr
lny										
--.	1.0000									
L1.	0.9986	1.0000								
yt	0.2414	0.2406	1.0000							
lnng	0.1431	0.1379	0.0275	1.0000						
lnSk	0.5822	0.5708	0.1231	0.6363	1.0000					
lnSh	-0.1150	-0.1091	-0.1896	0.3845	0.2889	1.0000				
lnrd	-0.2321	-0.2284	-0.5067	-0.6038	-0.6088	-0.1806	1.0000			
lnRT	0.6652	0.6562	0.5314	0.4259	0.8000	0.0072	-0.7656	1.0000		
lnTEUp	0.2381	0.2437	0.7324	0.2793	0.2748	0.0395	-0.8359	0.6218	1.0000	
lnTEUr	0.2381	0.2437	0.7324	0.2793	0.2748	0.0395	-0.8359	0.6218	1.0000	1.0000

```
. corr lny L.lny yt lnng lnSk lnSh lnrd lnRT lnTEUp lnTEUr if Year>=2009 & Year<=2015
(obs=59)
```

	lny	L. lny	yt	lnng	lnSk	lnSh	lnrd	lnRT	lnTEUp	lnTEUr
lny										
--.	1.0000									
L1.	0.9956	1.0000								
yt	-0.0930	-0.0792	1.0000							
lnng	-0.1363	-0.1502	0.2355	1.0000						
lnSk	0.7082	0.6995	0.1410	-0.0887	1.0000					
lnSh	-0.1474	-0.1315	-0.1067	0.4287	-0.0222	1.0000				
lnrd	-0.1220	-0.1296	-0.5239	-0.3213	-0.4186	-0.4357	1.0000			
lnRT	0.5355	0.5379	0.3557	-0.1213	0.7973	0.0811	-0.6449	1.0000		
lnTEUp	0.0580	0.0520	0.6008	0.2259	0.3356	0.1377	-0.7221	0.4500	1.0000	
lnTEUr	0.0507	0.0581	0.3878	0.1764	0.2436	0.1905	-0.6200	0.4310	0.5866	1.0000

A.5.3 Test results of the data

A.5.3.1 Unit roots test (IPS)

```
. xtunitroot ips lny, demean lags(1)

Im-Pesaran-Shin unit-root test for lny
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =     16
Ha: Some panels are stationary              Avg. number of periods =  25.50

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                     sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -2.3915        0.0084
------------------------------------------------------------------------------

. xtunitroot ips lnngd, demean lags(1)

Im-Pesaran-Shin unit-root test for lnngd
----------------------------------------
Ho: All panels contain unit roots           Number of panels       =     16
Ha: Some panels are stationary              Avg. number of periods =  21.50

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                     sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -2.8251        0.0024
------------------------------------------------------------------------------

. xtunitroot ips lnSk, demean lags(1)

Im-Pesaran-Shin unit-root test for lnSk
---------------------------------------
Ho: All panels contain unit roots           Number of panels       =     16
Ha: Some panels are stationary              Avg. number of periods =  20.81

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                     sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -3.9039        0.0000
------------------------------------------------------------------------------
```

```
. xtunitroot ips lnSh, demean lags(1)

Im-Pesaran-Shin unit-root test for lnSh
---------------------------------------
Ho: All panels contain unit roots           Number of panels       =     16
Ha: Some panels are stationary              Avg. number of periods =  25.50

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                        sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              -1.9691        0.0245
------------------------------------------------------------------------------
```

```
. xtunitroot ips lnrd, demean lags(1)

Im-Pesaran-Shin unit-root test for lnrd
---------------------------------------
Ho: All panels contain unit roots           Number of panels       =     16
Ha: Some panels are stationary              Avg. number of periods =  24.56

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                        sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              -1.3522        0.0881
------------------------------------------------------------------------------
```

```
. xtunitroot ips lnRT, demean lags(1)

Im-Pesaran-Shin unit-root test for lnRT
---------------------------------------
Ho: All panels contain unit roots           Number of panels  =     11
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                        sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                     Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              -1.2303        0.1093
------------------------------------------------------------------------------
```

```
. xtunitroot ips lnTEUp, demean lags(1)

Im-Pesaran-Shin unit-root test for lnTEUp
-----------------------------------------
Ho: All panels contain unit roots           Number of panels       =     11
Ha: Some panels are stationary              Avg. number of periods =  19.27

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              -7.5357       0.0000
------------------------------------------------------------------------------


. xtunitroot ips lnTEUr, demean lags(1)

Im-Pesaran-Shin unit-root test for lnTEUr
-----------------------------------------
Ho: All panels contain unit roots           Number of panels       =     11
Ha: Some panels are stationary              Avg. number of periods =  19.27

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included                  Cross-sectional means removed

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              -5.0488       0.0000
------------------------------------------------------------------------------
```

A.5.3.2 Co-integration test

```
. xtwest lny lnng, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Continuous time-series are required

Following series contain holes:
```

ID	Freq.
1	2
2	1
3	2
4	1
5	1
9	1
10	1
11	2
12	4
13	2
14	3
15	2

```
. xtwest y ngd, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.94
Average AIC selected lead length: 1.38
```

Statistic	Value	Z-value	P-value
Gt	-4.095	-8.661	0.000
Ga	-37.505	-15.398	0.000
Pt	-8.490	-0.045	0.482
Pa	-27.628	-12.505	0.000

```
. xtwest lny lnSk, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.88
Average AIC selected lead length: 1.38
```

Statistic	Value	Z-value	P-value
Gt	-2.780	-2.112	0.017
Ga	-10.383	0.911	0.819
Pt	-4.317	4.816	1.000
Pa	-13.814	-3.255	0.001

```
. xtwest lny lnSh, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.75
Average AIC selected lead length: .9400000000000001
```

Statistic	Value	Z-value	P-value
Gt	-3.010	-3.256	0.001
Ga	-25.702	-8.301	0.000
Pt	-6.292	2.515	0.994
Pa	-16.463	-5.029	0.000

```
. xtwest lny lnrd, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.81
Average AIC selected lead length: 1.44
```

Statistic	Value	Z-value	P-value
Gt	-3.733	-6.859	0.000
Ga	-19.836	-4.774	0.000
Pt	-6.843	1.874	0.970
Pa	-18.442	-6.354	0.000

```
. xtwest lny lnRT, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.91
Average AIC selected lead length: 1.09
```

Statistic	Value	Z-value	P-value
Gt	-2.028	1.354	0.912
Ga	-7.766	2.060	0.980
Pt	-4.357	3.087	0.999
Pa	-16.538	-4.211	0.000

```
. xtwest ngd Sk, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.75
Average AIC selected lead length: 1.13
```

Statistic	Value	Z-value	P-value
Gt	-5.596	-16.137	0.000
Ga	-8.972	1.759	0.961
Pt	-9.477	-1.194	0.116
Pa	-13.575	-3.095	0.001

```
. xtwest ngd Sh, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.94
Average AIC selected lead length: 1.69
```

Statistic	Value	Z-value	P-value
Gt	-3.609	-6.240	0.000
Ga	-8.484	2.053	0.980
Pt	-12.388	-4.585	0.000
Pa	-15.906	-4.656	0.000

```
. xtwest ngd rd, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.88
Average AIC selected lead length: 1.56
```

Statistic	Value	Z-value	P-value
Gt	-4.038	-8.380	0.000
Ga	-12.891	-0.597	0.275
Pt	-16.943	-9.890	0.000
Pa	-16.563	-5.096	0.000

```
. xtwest ngd RT, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.63
Average AIC selected lead length: .75
```

Statistic	Value	Z-value	P-value
Gt	-3.800	-7.190	0.000
Ga	-15.642	-2.252	0.012
Pt	-16.456	-9.324	0.000
Pa	-22.613	-9.147	0.000

```
. xtwest lnSk lnSh, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.94
Average AIC selected lead length: 1.56
```

Statistic	Value	Z-value	P-value
Gt	-7.649	-26.360	0.000
Ga	-29.010	-10.290	0.000
Pt	-19.905	-13.340	0.000
Pa	-31.698	-15.231	0.000

```
. xtwest lnSk lnrd, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.94
Average AIC selected lead length: 1.31
```

Statistic	Value	Z-value	P-value
Gt	-7.492	-25.580	0.000
Ga	-30.466	-11.166	0.000
Pt	-18.855	-12.118	0.000
Pa	-25.228	-10.898	0.000

```
. xtwest lnSk lnRT, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 2
Average AIC selected lead length: 1
```

Statistic	Value	Z-value	P-value
Gt	-9.686	-30.269	0.000
Ga	-39.270	-13.648	0.000
Pt	-23.934	-19.715	0.000
Pa	-43.641	-19.260	0.000

```
. xtwest lnSh lnrd, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.63
Average AIC selected lead length: .9400000000000001
```

Statistic	Value	Z-value	P-value
Gt	-3.123	-3.820	0.000
Ga	-25.854	-8.392	0.000
Pt	-11.796	-3.896	0.000
Pa	-22.787	-9.263	0.000

```
. xtwest lnSh lnRT, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.91
Average AIC selected lead length: 1.27
```

Statistic	Value	Z-value	P-value
Gt	-3.813	-6.018	0.000
Ga	-12.316	-0.209	0.417
Pt	-8.268	-1.468	0.071
Pa	-13.702	-2.636	0.004

```
. xtwest lnSh lnrd, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.63
Average AIC selected lead length: .9400000000000001
```

Statistic	Value	Z-value	P-value
Gt	-3.123	-3.820	0.000
Ga	-25.854	-8.392	0.000
Pt	-11.796	-3.896	0.000
Pa	-22.787	-9.263	0.000

```
. xtwest lnSh lnRT, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.91
Average AIC selected lead length: 1.27
```

Statistic	Value	Z-value	P-value
Gt	-3.813	-6.018	0.000
Ga	-12.316	-0.209	0.417
Pt	-8.268	-1.468	0.071
Pa	-13.702	-2.636	0.004

```
. xtwest lnrd lnRT, lags(1 2) leads(0 2) lrwindow(3) constant trend westerlund

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.55
Average AIC selected lead length: 1.36
```

Statistic	Value	Z-value	P-value
Gt	-3.555	-4.951	0.000
Ga	-17.867	-2.976	0.002
Pt	-11.999	-5.814	0.000
Pa	-24.521	-8.644	0.000

A.5.3.3 Co-integration test with regional dependence

```
. xtwest lny lnng, constant trend lags(1 2) leads(0 2) lrwindow(3)

Continuous time-series are required

Following series contain holes:
```

ID	Freq.
1	2
2	1
3	2
4	1
5	1
9	1
10	1
11	2
12	4
13	2
14	3
15	2

```
. xtwest y ngd, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 2
Average AIC selected lead length: 2
```

Statistic	Value	Z-value	P-value
Gt	-2.334	0.161	0.564
Ga	-4.463	4.440	1.000
Pt	-5.682	3.164	0.999
Pa	-2.547	4.166	1.000

```
. xtwest lny lnSk, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.38
Average AIC selected lead length: .5600000000000001
```

Statistic	Value	Z-value	P-value
Gt	-2.074	1.438	0.925
Ga	-4.304	4.534	1.000
Pt	-2.663	6.617	1.000
Pa	-2.829	3.982	1.000

```
. xtwest lny lnSh, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.25
Average AIC selected lead length: .25
```

Statistic	Value	Z-value	P-value
Gt	-2.104	1.290	0.902
Ga	-8.554	2.034	0.979
Pt	-5.487	3.388	1.000
Pa	-6.049	1.881	0.970

```
. xtwest lny lnrd, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.31
Average AIC selected lead length: .63
```

Statistic	Value	Z-value	P-value
Gt	-2.851	-2.386	0.009
Ga	-7.195	2.833	0.998
Pt	-6.115	2.670	0.996
Pa	-7.026	1.244	0.893

```
. xtwest lny lnRT, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.36
Average AIC selected lead length: .18
```

Statistic	Value	Z-value	P-value
Gt	-1.505	3.515	1.000
Ga	-4.042	3.887	1.000
Pt	-2.378	5.291	1.000
Pa	-3.197	3.102	0.999

```
. xtwest ngd Sk, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.75
Average AIC selected lead length: 1.19
```

Statistic	Value	Z-value	P-value
Gt	-3.393	-5.054	0.000
Ga	-3.500	5.007	1.000
Pt	-7.009	1.647	0.950
Pa	-7.376	1.016	0.845

```
. xtwest ngd Sh, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.75
Average AIC selected lead length: 1.75
```

Statistic	Value	Z-value	P-value
Gt	-2.423	-0.278	0.390
Ga	-3.167	5.202	1.000
Pt	-9.509	-1.212	0.113
Pa	-9.078	-0.095	0.462

```
. xtwest ngd rd, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.88
Average AIC selected lead length: 1.56
```

Statistic	Value	Z-value	P-value
Gt	-2.574	-1.022	0.153
Ga	-4.489	4.425	1.000
Pt	-13.091	-5.307	0.000
Pa	-9.442	-0.333	0.370

```
. xtwest ngd RT, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.63
Average AIC selected lead length: 1.19
```

Statistic	Value	Z-value	P-value
Gt	-2.736	-1.818	0.035
Ga	-6.064	3.498	1.000
Pt	-12.483	-4.612	0.000
Pa	-11.810	-1.877	0.030

```
. xtwest lnSk lnSh, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.75
Average AIC selected lead length: .6900000000000001
```

Statistic	Value	Z-value	P-value
Gt	-5.430	-15.079	0.000
Ga	-15.988	-2.339	0.010
Pt	-16.372	-9.058	0.000
Pa	-16.279	-4.793	0.000

```
. xtwest lnSk lnrd, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.88
Average AIC selected lead length: .38
```

Statistic	Value	Z-value	P-value
Gt	-5.646	-16.142	0.000
Ga	-15.647	-2.138	0.016
Pt	-14.850	-7.319	0.000
Pa	-20.002	-7.221	0.000

```
. xtwest lnSk lnRT, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.91
Average AIC selected lead length: .73
```

Statistic	Value	Z-value	P-value
Gt	-5.926	-14.530	0.000
Ga	-18.530	-3.179	0.001
Pt	-13.701	-7.655	0.000
Pa	-16.999	-4.363	0.000

```
. xtwest lnSh lnrd, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 16 series and 1 covariate
Average AIC selected lag length: 1.19
Average AIC selected lead length: .31
```

Statistic	Value	Z-value	P-value
Gt	-2.545	-0.877	0.190
Ga	-8.272	2.200	0.986
Pt	-9.679	-1.405	0.080
Pa	-8.924	0.006	0.502

```
. xtwest lnSh lnRT, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.27
Average AIC selected lead length: .36
```

Statistic	Value	Z-value	P-value
Gt	-2.684	-1.295	0.098
Ga	-6.218	2.826	0.998
Pt	-6.274	0.837	0.799
Pa	-5.477	1.869	0.969

```
. xtwest lnrd lnRT, constant trend lags(1 2) leads(0 2) lrwindow(3)

Calculating Westerlund ECM panel cointegration tests..........

Results for H0: no cointegration
With 11 series and 1 covariate
Average AIC selected lag length: 1.45
Average AIC selected lead length: 1.18
```

Statistic	Value	Z-value	P-value
Gt	-2.393	-0.110	0.456
Ga	-5.096	3.373	1.000
Pt	-9.579	-2.942	0.002
Pa	-10.832	-1.028	0.152

A.5.4 Preliminary test results

A.5.4.1 Test results for fitted model

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT

      Source |       SS           df       MS      Number of obs   =       213
-------------+----------------------------------   F(6, 206)       =   3742.15
       Model |  24.6554885         6  4.10924808   Prob > F        =    0.0000
    Residual |   .2262085        206   .0010981    R-squared       =    0.9909
-------------+----------------------------------   Adj R-squared   =    0.9906
       Total |   24.881697       212  .117366495   Root MSE        =    .03314

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0042462   .0032249    -1.32   0.189    -.0106043    .0021118
        lnSk |   .0366258   .0103999     3.52   0.001      .016122    .0571296
        lnSh |  -.0227626   .0073804    -3.08   0.002    -.0373135   -.0082117
             |
         lny |
         L1. |   .9806341   .0105721    92.76   0.000     .9597907    1.001477
             |
        lnrd |    -.00422   .0062951    -0.67   0.503    -.0166312    .0081911
        lnRT |  -.0045359   .0034214    -1.33   0.186    -.0112813    .0022095
       _cons |   .2948167   .0720642     4.09   0.000     .1527387    .4368946
------------------------------------------------------------------------------

. xtreg lny lnngd lnSk lnSh L.lny lnrd lnRT, re

Random-effects GLS regression                   Number of obs     =        213
Group variable: ID                              Number of groups  =         11

R-sq:                                           Obs per group:
     within  = 0.9749                                         min =         15
     between = 0.9993                                         avg =       19.4
     overall = 0.9909                                         max =         21

                                                Wald chi2(6)      =   14348.88
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0038446   .0034968    -1.10   0.272    -.0106981     .003009
        lnSk |   .0375258   .0122643     3.06   0.002     .0134882    .0615634
        lnSh |  -.0188127   .0088577    -2.12   0.034    -.0361734   -.0014519
             |
         lny |
         L1. |    .967707    .014434    67.04   0.000     .9394168    .9959972
             |
        lnrd |  -.0013876   .0083588    -0.17   0.868    -.0177706    .0149954
        lnRT |  -.0022952   .0045512    -0.50   0.614    -.0112155    .0066251
       _cons |   .3681711   .0959247     3.84   0.000     .1801622      .55618
-------------+----------------------------------------------------------------
     sigma_u |  .00852032
     sigma_e |  .03132909
         rho |  .06886954   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

```
. xtreg lny lnngd lnSk lnSh L.lny lnrd lnRT, fe

Fixed-effects (within) regression               Number of obs     =        213
Group variable: ID                              Number of groups  =         11

R-sq:                                           Obs per group:
     within  = 0.9769                                         min =         15
     between = 0.9933                                         avg =       19.4
     overall = 0.9819                                         max =         21

                                                F(6,196)          =    1378.45
corr(u_i, Xb)  = 0.6593                         Prob > F          =     0.0000

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0029453   .0036759    -0.80   0.424    -.0101947    .0043041
        lnSk |   .0290111   .0145668     1.99   0.048     .0002833    .0577388
        lnSh |   .0565004   .0220882     2.56   0.011     .0129393    .1000614
             |
         lny |
         L1. |   .8175619   .0355638    22.99   0.000      .747425    .8876988
             |
        lnrd |    .015305   .0210111     0.73   0.467    -.0261319    .0567419
        lnRT |   .0179165   .0119557     1.50   0.136    -.0056619    .0414949
       _cons |   1.353233   .2910208     4.65   0.000      .779299    1.927167
-------------+----------------------------------------------------------------
     sigma_u |  .04951865
     sigma_e |  .03132909
         rho |  .71414567   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(10, 196) = 3.45                     Prob > F = 0.0003
```

A.5.4.2 Test results for the multi-collinearity

```
. lmcol lny lnngd lnSk lnSh lnrd lnRT

==============================================================================
* Ordinary Least Squares (OLS)
==============================================================================
  lny = lnngd + lnSk + lnSh + lnrd + lnRT
------------------------------------------------------------------------------
  Sample Size       =         214
  Wald Test         =    318.0628   |   P-Value > Chi2(5)       =      0.0000
  F-Test            =     63.6126   |   P-Value > F(5 , 208)    =      0.0000
 (Buse 1973) R2     =      0.6046   |   Raw Moments R2          =      0.9996
 (Buse 1973) R2 Adj =      0.5951   |   Raw Moments R2 Adj      =      0.9996
  Root MSE (Sigma)  =      0.2186   |   Log Likelihood Function =     24.7388
------------------------------------------------------------------------------
- R2h= 0.6046   R2h Adj= 0.5951  F-Test =   63.61 P-Value > F(5 , 208) 0.0000
- R2v= 0.6046   R2v Adj= 0.5951  F-Test =   63.61 P-Value > F(5 , 208) 0.0000
------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0938233   .0201344     4.66   0.000     .0541297    .1335169
        lnSk |   .2769713    .065757     4.21   0.000     .1473358    .4066069
        lnSh |   .2777962   .0433453     6.41   0.000     .1923438    .3632486
        lnrd |   .3403709   .0336117    10.13   0.000     .2741077    .4066342
        lnRT |   .1725608   .0188493     9.15   0.000     .1354006     .209721
       _cons |   4.758971   .3521203    13.52   0.000     4.064788    5.453153
------------------------------------------------------------------------------

==============================================================================
*** Multicollinearity Diagnostic Tests
==============================================================================

* Correlation Matrix
(obs=214)

             |    lnngd     lnSk     lnSh     lnrd     lnRT
-------------+---------------------------------------------
       lnngd |   1.0000
        lnSk |   0.0512   1.0000
        lnSh |   0.1596  -0.1201   1.0000
        lnrd |  -0.1060  -0.1807  -0.0673   1.0000
        lnRT |  -0.1817   0.5724   0.0902  -0.5116   1.0000

* Multicollinearity Diagnostic Criteria
```

Var	Eigenval	C_Number	C_Index	VIF	1/VIF	R2_xi,X
lnngd	1.8653	1.0000	1.0000	1.2333	0.8108	0.1892
lnSk	1.2070	1.5454	1.2431	1.7398	0.5748	0.4252
lnSh	0.9363	1.9922	1.4114	1.1201	0.8927	0.1073
lnrd	0.7590	2.4576	1.5677	1.5119	0.6614	0.3386
lnRT	0.2325	8.0239	2.8327	2.4468	0.4087	0.5913

```
* Farrar-Glauber Multicollinearity Tests
  Ho: No Multicollinearity - Ha: Multicollinearity
--------------------------------------------------

* (1) Farrar-Glauber Multicollinearity Chi2-Test:
    Chi2 Test =  208.2023    P-Value > Chi2(10) 0.0000

* (2) Farrar-Glauber Multicollinearity F-Test:
```

Variable	F_Test	DF1	DF2	P_Value
lnngd	12.191	209.000	5.000	0.005
lnSk	38.652	209.000	5.000	0.000
lnSh	6.277	209.000	5.000	0.023
lnrd	26.747	209.000	5.000	0.001
lnRT	75.598	209.000	5.000	0.000

*** (3) Farrar-Glauber Multicollinearity t-Test:**

Variable	lnngd	lnSk	lnSh	lnrd	lnRT
lnngd	.				
lnSk	0.741	.			
lnSh	2.338	-1.749	.		
lnrd	-1.541	-2.657	-0.976	.	
lnRT	-2.671	10.091	1.310	-8.607	.

*** |X'X| Determinant:**
|X'X| = 0 Multicollinearity - |X'X| = 1 No Multicollinearity
|X'X| Determinant: (0 < 0.3719 < 1)

*** Theil R2 Multicollinearity Effect:**
R2 = 0 No Multicollinearity - R2 = 1 Multicollinearity
- Theil R2: (0 < 0.0973 < 1)

*** Multicollinearity Range:**
Q = 0 No Multicollinearity - Q = 1 Multicollinearity
- Gleason-Staelin Q0: (0 < 0.2686 < 1)
1- Heo Range Q1: (0 < 0.3939 < 1)
2- Heo Range Q2: (0 < 0.3790 < 1)
3- Heo Range Q3: (0 < 0.3902 < 1)
4- Heo Range Q4: (0 < 0.2279 < 1)
5- Heo Range Q5: (0 < 0.7882 < 1)
6- Heo Range Q6: (0 < 0.3303 < 1)

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT
```

Source	SS	df	MS
Model	24.6554885	6	4.10924808
Residual	.2262085	206	.0010981
Total	24.881697	212	.117366495

Number of obs	=	213
F(6, 206)	=	3742.15
Prob > F	=	0.0000
R-squared	=	0.9909
Adj R-squared	=	0.9906
Root MSE	=	.03314

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0042462	.0032249	-1.32	0.189	-.0106043	.0021118
lnSk	.0366258	.0103999	3.52	0.001	.016122	.0571296
lnSh	-.0227626	.0073804	-3.08	0.002	-.0373135	-.0082117
lny						
L1.	.9806341	.0105721	92.76	0.000	.9597907	1.001477
lnrd	-.00422	.0062951	-0.67	0.503	-.0166312	.0081911
lnRT	-.0045359	.0034214	-1.33	0.186	-.0112813	.0022095
_cons	.2948167	.0720642	4.09	0.000	.1527387	.4368946

```
. vif
```

Variable	VIF	1/VIF
lnRT	3.50	0.285936
lny		
L1.	2.63	0.380845
lnrd	2.31	0.433818
lnSk	1.89	0.528421
lnSh	1.41	0.708358
lnngd	1.38	0.726274
Mean VIF	2.18	

```
. lmcol lny lnngd lnSk lnSh lnrd lnTEUp

==============================================================================
* Ordinary Least Squares (OLS)
==============================================================================
  lny = lnngd + lnSk + lnSh + lnrd + lnTEUp
------------------------------------------------------------------------------
  Sample Size       =         176
  Wald Test         =    164.9744   |   P-Value > Chi2(5)       =      0.0000
  F-Test            =     32.9949   |   P-Value > F(5 , 170)    =      0.0000
 (Buse 1973) R2     =      0.4925   |   Raw Moments R2          =      0.9995
 (Buse 1973) R2 Adj =      0.4776   |   Raw Moments R2 Adj      =      0.9995
  Root MSE (Sigma)  =      0.2483   |   Log Likelihood Function =     -1.4870
------------------------------------------------------------------------------
- R2h= 0.4925   R2h Adj= 0.4776  F-Test =   32.99 P-Value > F(5 , 170) 0.0000
- R2v= 0.4925   R2v Adj= 0.4776  F-Test =   32.99 P-Value > F(5 , 170) 0.0000
```

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.063577	.0226072	2.81	0.005	.01895	.108204
lnSk	.8149503	.0723301	11.27	0.000	.6721694	.9577311
lnSh	.1603284	.0632236	2.54	0.012	.035524	.2851328
lnrd	.2071038	.0405076	5.11	0.000	.1271411	.2870664
lnTEUp	.0181219	.0084739	2.14	0.034	.0013943	.0348495
_cons	7.001334	.3316146	21.11	0.000	6.346722	7.655947

```
==============================================================================
*** Multicollinearity Diagnostic Tests
==============================================================================
```

*** Correlation Matrix**
(obs=176)

	lnngd	lnSk	lnSh	lnrd	lnTEUp
lnngd	1.0000				
lnSk	0.0570	1.0000			
lnSh	0.2387	0.0319	1.0000		
lnrd	-0.0802	-0.1494	-0.0624	1.0000	
lnTEUp	0.0073	0.0471	0.2758	-0.5830	1.0000

*** Multicollinearity Diagnostic Criteria**

Var	Eigenval	C_Number	C_Index	VIF	1/VIF	R2_xi,X
lnngd	1.7296	1.0000	1.0000	1.0840	0.9225	0.0775
lnSk	1.1473	1.5075	1.2278	1.0282	0.9726	0.0274
lnSh	0.9944	1.7393	1.3188	1.1814	0.8465	0.1535
lnrd	0.7770	2.2261	1.4920	1.6009	0.6247	0.3753
lnT~p	0.3516	4.9190	2.2179	1.6919	0.5911	0.4089

```
* Farrar-Glauber Multicollinearity Tests
  Ho: No Multicollinearity - Ha: Multicollinearity
--------------------------------------------------

* (1) Farrar-Glauber Multicollinearity Chi2-Test:
    Chi2 Test =  106.5663    P-Value > Chi2(10) 0.0000

* (2) Farrar-Glauber Multicollinearity F-Test:
```

Variable	F_Test	DF1	DF2	P_Value
lnngd	3.593	171.000	5.000	0.075
lnSk	1.205	171.000	5.000	0.470
lnSh	7.753	171.000	5.000	0.014
lnrd	25.688	171.000	5.000	0.001
lnTEUp	29.577	171.000	5.000	0.001

```
* (3) Farrar-Glauber Multicollinearity t-Test:
```

Variable	lnngd	lnSk	lnSh	lnrd	lnTEUp
lnngd	.				
lnSk	0.747	.			
lnSh	3.215	0.418	.		
lnrd	-1.052	-1.976	-0.817	.	
lnTEUp	0.095	0.617	3.752	-9.383	.

```
* |X'X| Determinant:
  |X'X| = 0 Multicollinearity - |X'X| = 1 No Multicollinearity
  |X'X| Determinant:       (0 < 0.5391 < 1)
---------------------------------------------------------------

* Theil R2 Multicollinearity Effect:
  R2 = 0 No Multicollinearity - R2 = 1 Multicollinearity
     - Theil R2:           (0 < -0.0210 < 1)
---------------------------------------------------------------

* Multicollinearity Range:
  Q = 0 No Multicollinearity - Q = 1 Multicollinearity
     - Gleason-Staelin Q0: (0 < 0.2263 < 1)
    1- Heo Range Q1:       (0 < 0.2037 < 1)
    2- Heo Range Q2:       (0 < 0.2409 < 1)
    3- Heo Range Q3:       (0 < 0.2657 < 1)
    4- Heo Range Q4:       (0 < 0.2035 < 1)
    5- Heo Range Q5:       (0 < 0.6945 < 1)
    6- Heo Range Q6:       (0 < 0.2085 < 1)
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnTEUp
```

Source	SS	df	MS			
				Number of obs	=	175
				F(6, 168)	=	3361.86
Model	20.2609292	6	3.37682154	Prob > F	=	0.0000
Residual	.168747491	168	.001004449	R-squared	=	0.9917
				Adj R-squared	=	0.9914
Total	20.4296767	174	.117411935	Root MSE	=	.03169

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0030197	.0029597	-1.02	0.309	-.0088626	.0028233
lnSk	.0347977	.0121943	2.85	0.005	.0107238	.0588715
lnSh	-.0165627	.0083129	-1.99	0.048	-.0329738	-.0001515
lny						
L1.	.9770275	.0098582	99.11	0.000	.9575657	.9964893
lnrd	-.0026984	.0056072	-0.48	0.631	-.0137681	.0083713
lnTEUp	-.0009053	.0010987	-0.82	0.411	-.0030743	.0012637
_cons	.2428632	.079684	3.05	0.003	.0855522	.4001743

```
. vif
```

Variable	VIF	1/VIF
lny		
L1.	2.01	0.496357
lnrd	1.88	0.531959
lnSk	1.79	0.558256
lnTEUp	1.75	0.572889
lnSh	1.25	0.801395
lnngd	1.14	0.877414
Mean VIF	1.64	

```
. lmcol lny lnngd lnSk lnSh lnrd lnTEUr

==============================================================================
* Ordinary Least Squares (OLS)
==============================================================================
  lny = lnngd + lnSk + lnSh + lnrd + lnTEUr
------------------------------------------------------------------------------
  Sample Size       =         176
  Wald Test         =    166.8175   |   P-Value > Chi2(5)       =      0.0000
  F-Test            =     33.3635   |   P-Value > F(5 , 170)    =      0.0000
 (Buse 1973) R2     =      0.4953   |   Raw Moments R2          =      0.9995
 (Buse 1973) R2 Adj =      0.4804   |   Raw Moments R2 Adj      =      0.9995
  Root MSE (Sigma)  =      0.2476   |   Log Likelihood Function =     -1.0041
------------------------------------------------------------------------------
- R2h= 0.4953   R2h Adj= 0.4804  F-Test =   33.36 P-Value > F(5 , 170) 0.0000
- R2v= 0.4953   R2v Adj= 0.4804  F-Test =   33.36 P-Value > F(5 , 170) 0.0000
------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0629128    .022485     2.80   0.006      .018527    .1072985
        lnSk |   .8123711   .0720679    11.27   0.000     .6701079    .9546343
        lnSh |   .1482898   .0641909     2.31   0.022     .0215759    .2750038
        lnrd |   .2052125   .0387147     5.30   0.000      .128789     .281636
      lnTEUr |   .0193207    .008213     2.35   0.020     .0031081    .0355333
       _cons |   7.031461   .3207423    21.92   0.000      6.39831    7.664612
------------------------------------------------------------------------------

==============================================================================
*** Multicollinearity Diagnostic Tests
==============================================================================

* Correlation Matrix
(obs=176)

             |    lnngd     lnSk     lnSh     lnrd   lnTEUr
-------------+---------------------------------------------
       lnngd |   1.0000
        lnSk |   0.0570   1.0000
        lnSh |   0.2387   0.0319   1.0000
        lnrd |  -0.0802  -0.1494  -0.0624   1.0000
      lnTEUr |   0.0328   0.0561   0.3290  -0.5321   1.0000

* Multicollinearity Diagnostic Criteria
```

Var	Eigenval	C_Number	C_Index	VIF	1/VIF	R2_xi,X
lnngd	1.7282	1.0000	1.0000	1.0783	0.9274	0.0726
lnSk	1.1171	1.5470	1.2438	1.0264	0.9743	0.0257
lnSh	0.9940	1.7386	1.3186	1.2245	0.8167	0.1833
lnrd	0.7836	2.2055	1.4851	1.4704	0.6801	0.3199
lnT~r	0.3770	4.5837	2.1410	1.6088	0.6216	0.3784

```
* Farrar-Glauber Multicollinearity Tests
  Ho: No Multicollinearity - Ha: Multicollinearity
--------------------------------------------------

* (1) Farrar-Glauber Multicollinearity Chi2-Test:
    Chi2 Test =   97.8811    P-Value > Chi2(10) 0.0000

* (2) Farrar-Glauber Multicollinearity F-Test:
```

Variable	F_Test	DF1	DF2	P_Value
lnngd	3.346	171.000	5.000	0.087
lnSk	1.127	171.000	5.000	0.509
lnSh	9.597	171.000	5.000	0.009
lnrd	20.108	171.000	5.000	0.002
lnTEUr	26.025	171.000	5.000	0.001

*** (3) Farrar-Glauber Multicollinearity t-Test:**

Variable	lnngd	lnSk	lnSh	lnrd	lnTEUr
lnngd	.				
lnSk	0.747	.			
lnSh	3.215	0.418	.		
lnrd	-1.052	-1.976	-0.817	.	
lnTEUr	0.429	0.734	4.555	-8.218	.

```
* |X'X| Determinant:
  |X'X| = 0 Multicollinearity - |X'X| = 1 No Multicollinearity
  |X'X| Determinant:       (0 < 0.5670 < 1)
---------------------------------------------------------------

* Theil R2 Multicollinearity Effect:
  R2 = 0 No Multicollinearity - R2 = 1 Multicollinearity
     - Theil R2:           (0 < -0.0209 < 1)
---------------------------------------------------------------

* Multicollinearity Range:
  Q = 0 No Multicollinearity - Q = 1 Multicollinearity
     - Gleason-Staelin Q0: (0 < 0.2212 < 1)
    1- Heo Range Q1:       (0 < 0.1786 < 1)
    2- Heo Range Q2:       (0 < 0.2198 < 1)
    3- Heo Range Q3:       (0 < 0.2470 < 1)
    4- Heo Range Q4:       (0 < 0.2032 < 1)
    5- Heo Range Q5:       (0 < 0.6757 < 1)
    6- Heo Range Q6:       (0 < 0.1960 < 1)
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnTEUr

      Source |       SS           df       MS      Number of obs   =       175
-------------+----------------------------------   F(6, 168)       =   3376.90
       Model |  20.2616744         6  3.37694573   Prob > F        =    0.0000
    Residual |  .168002344       168  .001000014   R-squared       =    0.9918
-------------+----------------------------------   Adj R-squared   =    0.9915
       Total |  20.4296767       174  .117411935   Root MSE        =    .03162

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0031252   .0029448    -1.06   0.290    -.0089388    .0026883
        lnSk |   .0341326   .0121634     2.81   0.006     .0101198    .0581454
        lnSh |  -.0152844   .0084077    -1.82   0.071    -.0318828     .001314
             |
         lny |
         L1. |   .9779038   .0098736    99.04   0.000     .9584115    .9973961
             |
        lnrd |   -.003553   .0053955    -0.66   0.511    -.0142048    .0070988
      lnTEUr |  -.0012776   .0010694    -1.19   0.234    -.0033888    .0008337
       _cons |   .2394866   .0792955     3.02   0.003     .0829425    .3960306
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         lny |
         L1. |      2.03    0.492621
        lnSk |      1.79    0.558619
        lnrd |      1.75    0.571985
      lnTEUr |      1.67    0.597945
        lnSh |      1.28    0.779956
       lnngd |      1.13    0.882387
-------------+----------------------
    Mean VIF |      1.61
```

A.5.5 Results of estimating parameters

A.5.5.1 Overall analysis (1990 to 2015)

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       316
Method: Fixed-effects regression                 Number of groups  =        16
Group variable (i): ID                           F(  5,     20)     =   1955.39
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9763
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0018546	.0046416	-0.40	0.694	-.0115368	.0078275
lnSk	.0300228	.0232311	1.29	0.211	-.0184363	.078482
lnSh	.0644862	.018457	3.49	0.002	.0259856	.1029869
lny						
L1.	.8233027	.033099	24.87	0.000	.7542594	.892346
lnrd	.0168218	.0229668	0.73	0.472	-.0310862	.0647298
_cons	1.565233	.3189377	4.91	0.000	.8999408	2.230526

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       213
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     20)     =   1178.23
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9769
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0029453	.0051727	-0.57	0.575	-.0137353	.0078448
lnSk	.0290111	.0251936	1.15	0.263	-.0235418	.081564
lnSh	.0565004	.0185137	3.05	0.006	.0178815	.0951192
lny						
L1.	.8175619	.0364209	22.45	0.000	.7415891	.8935347
lnrd	.015305	.0250837	0.61	0.549	-.0370187	.0676288
lnRT	.0179165	.0056379	3.18	0.005	.0061561	.0296769
_cons	1.353233	.3641613	3.72	0.001	.593606	2.11286

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       175
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,    20)     =    734.81
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9651
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0019073	.0047165	-0.40	0.690	-.0117458	.0079312
lnSk	.0424978	.0279259	1.52	0.144	-.0157546	.1007503
lnSh	.0843212	.0235193	3.59	0.002	.0352608	.1333816
lny						
L1.	.7488875	.0467586	16.02	0.000	.6513508	.8464242
lnrd	.0418336	.0240468	1.74	0.097	-.0083271	.0919944
lnTEUp	.0008041	.0015178	0.53	0.602	-.0023618	.0039701
_cons	2.179088	.3711707	5.87	0.000	1.404839	2.953336

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       175
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,    20)     =    709.78
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9653
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0020181	.0045852	-0.44	0.665	-.0115827	.0075465
lnSk	.0463168	.03207	1.44	0.164	-.0205801	.1132137
lnSh	.0862096	.0228075	3.78	0.001	.038634	.1337853
lny						
L1.	.7330069	.056796	12.91	0.000	.6145325	.8514813
lnrd	.044143	.0257342	1.72	0.102	-.0095375	.0978236
lnTEUr	.0020353	.0028953	0.70	0.490	-.0040043	.0080748
_cons	2.309015	.4215228	5.48	0.000	1.429734	3.188296

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       213
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  7,    20)     =   1245.27
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9769
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0029647	.0051691	-0.57	0.573	-.0137474	.0078179
lnSk	.0308098	.0266101	1.16	0.261	-.0246979	.0863176
lnSh	.0556806	.0190178	2.93	0.008	.01601	.0953511
lny						
L1.	.8157424	.0358436	22.76	0.000	.740974	.8905107
lnrd	.0171044	.0250984	0.68	0.503	-.03525	.0694588
lnRT	.0172797	.0055396	3.12	0.005	.0057242	.0288351
ConP	.0041994	.0058624	0.72	0.482	-.0080293	.0164281
_cons	1.372761	.353012	3.89	0.001	.6363909	2.109131

A.5.5.2 Results of the sub-periods analysis

A.5.5.2.1 Results of regression between 1994 and 2000

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd if Year>=1994 & Year<=2000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        87
Method: Fixed-effects regression                 Number of groups  =        16
Group variable (i): ID                           F(  5,     5)     =  16471.68
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7358

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0169488   .0031633    -5.36   0.003    -.0250804   -.0088172
        lnSk |   .0767001   .0335694     2.28   0.071    -.0095928     .162993
        lnSh |   .1272394   .0399136     3.19   0.024     .0246382    .2298406
             |
         lny |
         L1. |    .564504    .091696     6.16   0.002     .3287919    .8002161
             |
        lnrd |   .1071657   .1040986     1.03   0.350    -.1604284    .3747598
       _cons |   3.639696    .534654     6.81   0.001     2.265324    5.014068
------------------------------------------------------------------------------
```

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT if Year>=1994 & Year<=2000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        59
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     5)     =   4533.62
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7427

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0255901   .0087731    -2.92   0.033    -.0481422   -.0030381
        lnSk |   .0334843    .022636     1.48   0.199    -.0247035    .0916721
        lnSh |    .105117   .0359012     2.93   0.033     .0128301    .1974039
             |
         lny |
         L1. |   .4174353   .1396219     2.99   0.030     .0585258    .7763448
             |
        lnrd |   .0471882   .1100212     0.43   0.686    -.2356302    .3300066
        lnRT |   .1090428   .0438214     2.49   0.055    -.0036038    .2216893
       _cons |   3.647659   .4059184     8.99   0.000     2.604212    4.691105
------------------------------------------------------------------------------
```

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp if Year>=1994 & Year<=2000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        31
Method: Fixed-effects regression                 Number of groups  =         9
Group variable (i): ID                           F(  6,     5)     =    277.81
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.4662
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0153512	.0045598	-3.37	0.020	-.0270726	-.0036298
lnSk	.0594906	.0441367	1.35	0.236	-.0539662	.1729475
lnSh	.0883159	.1194245	0.74	0.493	-.2186746	.3953064
lny						
L1.	.3290239	.1541366	2.13	0.086	-.0671969	.7252446
lnrd	.1426397	.1442481	0.99	0.368	-.2281619	.5134414
lnTEUp	.0005942	.0112713	0.05	0.960	-.0283798	.0295681
_cons	6.119253	1.017064	6.02	0.002	3.504806	8.7337

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr if Year>=1994 & Year<=2000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        31
Method: Fixed-effects regression                 Number of groups  =         9
Group variable (i): ID                           F(  6,     5)     =    277.81
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.4662
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0153512	.0045598	-3.37	0.020	-.0270726	-.0036298
lnSk	.0594906	.0441367	1.35	0.236	-.0539662	.1729475
lnSh	.0883159	.1194245	0.74	0.493	-.2186746	.3953064
lny						
L1.	.3290239	.1541366	2.13	0.086	-.0671969	.7252446
lnrd	.1426397	.1442481	0.99	0.368	-.2281619	.5134414
lnTEUr	.0005942	.0112713	0.05	0.960	-.0283798	.0295681
_cons	6.119253	1.017064	6.02	0.002	3.504806	8.7337

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP if Year>=1994 & Year<=2000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        59
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  7,      5)    =    223.39
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7453
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0273596	.0094395	-2.90	0.034	-.0516245	-.0030947
lnSk	.0366258	.0240346	1.52	0.188	-.0251571	.0984087
lnSh	.0951249	.0406642	2.34	0.066	-.0094058	.1996557
lny						
L1.	.4048398	.145744	2.78	0.039	.0301931	.7794866
lnrd	.0494185	.1122063	0.44	0.678	-.2390169	.337854
lnRT	.1146016	.0459073	2.50	0.055	-.0034068	.2326101
ConP	.0280044	.0293091	0.96	0.383	-.0473371	.1033459
_cons	3.681312	.4416148	8.34	0.000	2.546105	4.816519

A.5.5.2.2 Results of regression between 2001 and 2008

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd if Year>=2001 & Year<=2008, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       118
Method: Fixed-effects regression                 Number of groups  =        16
Group variable (i): ID                           F(  5,      7)    =   8078.10
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9441
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0052607	.0032065	-1.64	0.145	-.0128429	.0023216
lnSk	-.0285264	.0220243	-1.30	0.236	-.0806057	.0235528
lnSh	.0848877	.01135	7.48	0.000	.0580493	.1117262
lny						
L1.	.8216422	.01946	42.22	0.000	.7756266	.8676578
lnrd	.0492568	.0231511	2.13	0.071	-.005487	.1040005
_cons	1.569562	.1475186	10.64	0.000	1.220736	1.918388

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT if Year>=2001 & Year<=2008, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        78
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,      7)    =   5047.18
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9534
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0050123	.003573	-1.40	0.203	-.013461	.0034364
lnSk	-.0209435	.0221373	-0.95	0.376	-.0732898	.0314029
lnSh	.0541532	.0187523	2.89	0.023	.0098111	.0984954
lny						
L1.	.864264	.0434336	19.90	0.000	.7615599	.9669682
lnrd	.0413912	.0453677	0.91	0.392	-.0658863	.1486688
lnRT	.0208649	.0163874	1.27	0.244	-.0178851	.0596148
_cons	.8599608	.1937953	4.44	0.003	.4017078	1.318214

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp if Year>=2001 & Year<=2008, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        68
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,      7)    =   3259.94
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9375
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0037992	.0038466	-0.99	0.356	-.0128949	.0052965
lnSk	-.0332587	.0275274	-1.21	0.266	-.0983508	.0318333
lnSh	.057918	.0181733	3.19	0.015	.0149449	.100891
lny						
L1.	.8404909	.0680892	12.34	0.000	.6794856	1.001496
lnrd	.0712439	.0799587	0.89	0.403	-.1178284	.2603161
lnTEUp	-.0002759	.0049459	-0.06	0.957	-.0119712	.0114194
_cons	1.394641	.4380643	3.18	0.015	.3587834	2.430498

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr if Year>=2001 & Year<=2008, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        68
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     7)     =   3259.94
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9375
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0037992	.0038466	-0.99	0.356	-.0128949	.0052965
lnSk	-.0332587	.0275274	-1.21	0.266	-.0983508	.0318333
lnSh	.057918	.0181733	3.19	0.015	.0149449	.100891
lny						
L1.	.8404909	.0680892	12.34	0.000	.6794856	1.001496
lnrd	.0712439	.0799587	0.89	0.403	-.1178284	.2603161
lnTEUr	-.0002759	.0049459	-0.06	0.957	-.0119712	.0114194
_cons	1.394641	.4380643	3.18	0.015	.3587834	2.430498

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP if Year>=2001 & Year<=2008, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        78
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  7,     7)     =   4847.54
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9537
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0053694	.003757	-1.43	0.196	-.0142532	.0035144
lnSk	-.0217348	.0222841	-0.98	0.362	-.0744282	.0309586
lnSh	.054946	.0193247	2.84	0.025	.0092503	.1006416
lny						
L1.	.8695226	.0489712	17.76	0.000	.7537242	.985321
lnrd	.0347127	.0491356	0.71	0.503	-.0814745	.1508999
lnRT	.0215585	.0161963	1.33	0.225	-.0167396	.0598566
ConP	-.0096381	.0091337	-1.06	0.326	-.0312358	.0119597
_cons	.8201968	.2189166	3.75	0.007	.3025412	1.337852

A.5.5.2.3 Results of regression between 2009 and 2015

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd if Year>=2009 & Year<=2015, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       111
Method: Fixed-effects regression                 Number of groups  =        16
Group variable (i): ID                           F(  5,      6)    =     26.92
maximum lag: 2                                   Prob > F          =    0.0005
                                                 within R-squared  =    0.7005
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.015897	.0106392	1.49	0.186	-.0101362	.0419302
lnSk	.0722834	.0281433	2.57	0.042	.0034193	.1411475
lnSh	.0393603	.0112519	3.50	0.013	.0118279	.0668926
lny						
L1.	.6249399	.059388	10.52	0.000	.4796227	.7702572
lnrd	.009045	.0044364	2.04	0.088	-.0018105	.0199005
_cons	3.683312	.6843948	5.38	0.002	2.008658	5.357965

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT if Year>=2009 & Year<=2015, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        76
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,      6)    =    305.68
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7415
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0351114	.0094469	3.72	0.010	.0119957	.058227
lnSk	.0513485	.0220834	2.33	0.059	-.0026877	.1053847
lnSh	.0544214	.0240653	2.26	0.064	-.0044644	.1133072
lny						
L1.	.4445975	.0474503	9.37	0.000	.3284908	.5607042
lnrd	.0045828	.0098984	0.46	0.660	-.0196378	.0288034
lnRT	.0511734	.0235106	2.18	0.072	-.006355	.1087017
_cons	4.752649	.4600427	10.33	0.000	3.626965	5.878333

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp if Year>=2009 & Year<=2015, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        76
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     6)     =  10594.52
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7325
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0364626	.0081764	4.46	0.004	.0164558	.0564694
lnSk	.0673065	.0286506	2.35	0.057	-.0027989	.1374118
lnSh	.0576977	.0178656	3.23	0.018	.0139822	.1014132
lny						
L1.	.5136607	.0378479	13.57	0.000	.4210503	.6062712
lnrd	.0073702	.0066167	1.11	0.308	-.0088204	.0235607
lnTEUp	.0073627	.002232	3.30	0.016	.0019012	.0128241
_cons	4.773776	.3819705	12.50	0.000	3.839127	5.708424

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr if Year>=2009 & Year<=2015, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        76
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     6)     =   1992.01
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7271
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0389451	.0090749	4.29	0.005	.0167395	.0611506
lnSk	.0649545	.0257429	2.52	0.045	.0019639	.127945
lnSh	.0558901	.0177524	3.15	0.020	.0124515	.0993287
lny						
L1.	.5281297	.0372418	14.18	0.000	.4370024	.619257
lnrd	.0044055	.0066915	0.66	0.535	-.011968	.020779
lnTEUr	.0042597	.0024596	1.73	0.134	-.0017586	.0102781
_cons	4.675223	.3884211	12.04	0.000	3.724791	5.625656

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP if Year>=2009 & Year<=2015, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        76
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  7,      6)    =    707.75
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.7429
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0342182	.0085371	4.01	0.007	.0133287	.0551076
lnSk	.0522999	.0227827	2.30	0.061	-.0034475	.1080472
lnSh	.0561956	.0238887	2.35	0.057	-.0022579	.1146492
lny						
L1.	.4345748	.0513155	8.47	0.000	.3090104	.5601393
lnrd	.0066213	.0087691	0.76	0.479	-.014836	.0280785
lnRT	.0513581	.023713	2.17	0.073	-.0066655	.1093817
ConP	.006009	.006594	0.91	0.397	-.010126	.022144
_cons	4.838835	.4155964	11.64	0.000	3.821908	5.855763

A.5.5.3 Results of the sub-regional analysis

A.5.5.3.1 The model with RT

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       213
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,    20)     =   1178.23
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9769
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0029453	.0051727	-0.57	0.575	-.0137353	.0078448
lnSk	.0290111	.0251936	1.15	0.263	-.0235418	.081564
lnSh	.0565004	.0185137	3.05	0.006	.0178815	.0951192
lny						
L1.	.8175619	.0364209	22.45	0.000	.7415891	.8935347
lnrd	.015305	.0250837	0.61	0.549	-.0370187	.0676288
lnRT	.0179165	.0056379	3.18	0.005	.0061561	.0296769
_cons	1.353233	.3641613	3.72	0.001	.593606	2.11286

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT if RT>=0 &RT<=80000000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       128
Method: Fixed-effects regression                 Number of groups  =         7
Group variable (i): ID                           F(  6,    20)     =   1030.07
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9723
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0027578	.0070552	-0.39	0.700	-.0174748	.0119592
lnSk	.0405593	.029801	1.36	0.189	-.0216044	.102723
lnSh	.0619101	.0197518	3.13	0.005	.0207085	.1031117
lny						
L1.	.827865	.044244	18.71	0.000	.7355735	.9201564
lnrd	.0071511	.0324445	0.22	0.828	-.060527	.0748292
lnRT	.0095166	.0167516	0.57	0.576	-.0254266	.0444597
_cons	1.372163	.5053473	2.72	0.013	.3180275	2.4263

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT if RT>=80000000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        85
Method: Fixed-effects regression                 Number of groups  =         6
Group variable (i): ID                           F(  6,    20)     =    962.16
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9745
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0024418	.0056149	-0.43	0.668	-.0141542	.0092706
lnSk	-.0058254	.03193	-0.18	0.857	-.0724303	.0607795
lnSh	.1182217	.0256433	4.61	0.000	.0647308	.1717126
lny						
L1.	.5946708	.0511722	11.62	0.000	.4879274	.7014142
lnrd	.0540379	.0468679	1.15	0.263	-.0437269	.1518027
lnRT	.0673973	.0206017	3.27	0.004	.0244229	.1103717
_cons	2.610764	.5183367	5.04	0.000	1.529533	3.691996

A.5.5.3.2 The model with TEUp

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       175
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,    20)     =    734.81
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9651
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0019073	.0047165	-0.40	0.690	-.0117458	.0079312
lnSk	.0424978	.0279259	1.52	0.144	-.0157546	.1007503
lnSh	.0843212	.0235193	3.59	0.002	.0352608	.1333816
lny						
L1.	.7488875	.0467586	16.02	0.000	.6513508	.8464242
lnrd	.0418336	.0240468	1.74	0.097	-.0083271	.0919944
lnTEUp	.0008041	.0015178	0.53	0.602	-.0023618	.0039701
_cons	2.179088	.3711707	5.87	0.000	1.404839	2.953336

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp if TEUp>=0 & TEUp<=100000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        85
Method: Fixed-effects regression                 Number of groups  =         8
Group variable (i): ID                           F(  6,    20)     =    173.28
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9512

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0052916   .0061024     0.87   0.396    -.0074377    .0180209
        lnSk |   .0651576   .0379221     1.72   0.101    -.0139466    .1442617
        lnSh |    .075718   .0255671     2.96   0.008     .0223859    .1290501
             |
         lny |
         L1. |   .7632236   .0537969    14.19   0.000     .6510053     .875442
             |
        lnrd |   .0296168   .0217845     1.36   0.189    -.0158248    .0750585
      lnTEUp |  -.0004616    .001328    -0.35   0.732    -.0032317    .0023085
       _cons |   2.027196   .4628654     4.38   0.000     1.061676    2.992717
------------------------------------------------------------------------------
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUp if TEUp>=100000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        90
Method: Fixed-effects regression                 Number of groups  =         8
Group variable (i): ID                           F(  6,    20)     =   1039.22
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9670

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0003527    .007541     0.05   0.963    -.0153775    .0160829
        lnSk |   -.005252   .0327498    -0.16   0.874     -.073567    .0630629
        lnSh |   .1099941   .0420921     2.61   0.017     .0221914    .1977967
             |
         lny |
         L1. |   .5705679    .138175     4.13   0.001     .2823398     .858796
             |
        lnrd |   .0696337     .06052     1.15   0.263    -.0566087    .1958762
      lnTEUp |   .0392211    .016755     2.34   0.030     .0042708    .0741714
       _cons |    3.54655   1.037561     3.42   0.003     1.382235    5.710866
------------------------------------------------------------------------------
```

A.5.5.3.3 The model with TEUr

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       175
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     20)    =    709.78
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9653
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0020181	.0045852	-0.44	0.665	-.0115827	.0075465
lnSk	.0463168	.03207	1.44	0.164	-.0205801	.1132137
lnSh	.0862096	.0228075	3.78	0.001	.038634	.1337853
lny						
L1.	.7330069	.056796	12.91	0.000	.6145325	.8514813
lnrd	.044143	.0257342	1.72	0.102	-.0095375	.0978236
lnTEUr	.0020353	.0028953	0.70	0.490	-.0040043	.0080748
_cons	2.309015	.4215228	5.48	0.000	1.429734	3.188296

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr if TEUr>=0 & TEUr<=100000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        78
Method: Fixed-effects regression                 Number of groups  =         8
Group variable (i): ID                           F(  6,     20)    =    173.24
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9412
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0071231	.0079677	0.89	0.382	-.0094972	.0237434
lnSk	.0853005	.056092	1.52	0.144	-.0317053	.2023064
lnSh	.0940002	.0228001	4.12	0.001	.0464401	.1415604
lny						
L1.	.6891429	.1026628	6.71	0.000	.4749921	.9032936
lnrd	.0380628	.0220157	1.73	0.099	-.0078611	.0839867
lnTEUr	.001269	.0032961	0.38	0.704	-.0056066	.0081446
_cons	2.651498	.863156	3.07	0.006	.8509856	4.45201

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnTEUr if TEUr>=100000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        97
Method: Fixed-effects regression                 Number of groups  =         9
Group variable (i): ID                           F(  6,    20)     =    900.03
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9618
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0004438	.0077483	-0.06	0.955	-.0166064	.0157187
lnSk	-.003905	.030346	-0.13	0.899	-.0672058	.0593957
lnSh	.0967948	.0445011	2.18	0.042	.0039672	.1896224
lny						
L1.	.6627851	.1256092	5.28	0.000	.4007689	.9248012
lnrd	.0561437	.0590686	0.95	0.353	-.0670712	.1793586
lnTEUr	.0211757	.0111801	1.89	0.073	-.0021456	.044497
_cons	2.884686	.9603197	3.00	0.007	.8814946	4.887878

A.5.5.3.4 The model with RT & ConP

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       213
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  7,    20)     =   1245.27
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9769
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0029647	.0051691	-0.57	0.573	-.0137474	.0078179
lnSk	.0308098	.0266101	1.16	0.261	-.0246979	.0863176
lnSh	.0556806	.0190178	2.93	0.008	.01601	.0953511
lny						
L1.	.8157424	.0358436	22.76	0.000	.740974	.8905107
lnrd	.0171044	.0250984	0.68	0.503	-.03525	.0694588
lnRT	.0172797	.0055396	3.12	0.005	.0057242	.0288351
ConP	.0041994	.0058624	0.72	0.482	-.0080293	.0164281
_cons	1.372761	.353012	3.89	0.001	.6363909	2.109131

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP if RT>=0 &RT<=80000000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       128
Method: Fixed-effects regression                 Number of groups  =         7
Group variable (i): ID                           F(  7,     20)    =   1167.01
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9725
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0029959	.0071431	-0.42	0.679	-.0178961	.0119043
lnSk	.0430547	.0296295	1.45	0.162	-.0187513	.1048607
lnSh	.060585	.018961	3.20	0.005	.021033	.100137
lny						
L1.	.818592	.0440612	18.58	0.000	.7266819	.9105021
lnrd	.0150992	.0321209	0.47	0.643	-.0519038	.0821021
lnRT	.0078818	.0157518	0.50	0.622	-.024976	.0407396
ConP	.0119325	.0083591	1.43	0.169	-.0055043	.0293692
_cons	1.461878	.476268	3.07	0.006	.4684008	2.455356

```
. xtscc lny lnngd lnSk lnSh L.lny lnrd lnRT ConP if RT>=80000000, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =        85
Method: Fixed-effects regression                 Number of groups  =         6
Group variable (i): ID                           F(  7,     20)    =    857.39
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9745
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0024098	.0056906	-0.42	0.676	-.0142801	.0094606
lnSk	-.0097725	.0300185	-0.33	0.748	-.0723901	.0528451
lnSh	.1195063	.0250888	4.76	0.000	.067172	.1718407
lny						
L1.	.5994129	.0573497	10.45	0.000	.4797835	.7190423
lnrd	.0524553	.0461399	1.14	0.269	-.0437908	.1487015
lnRT	.0665605	.0219018	3.04	0.006	.0208742	.1122468
ConP	-.006092	.0191369	-0.32	0.754	-.0460108	.0338269
_cons	2.593839	.5264133	4.93	0.000	1.49576	3.691918

A.5.6 Granger causality test

A.5.6.1 Test results for the proper lagged value

```
. xtscc lny L.lny L.lnRT, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       227
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  2,    20)     =   2008.79
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9753
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny						
L1.	.9281178	.0220462	42.10	0.000	.8821302	.9741054
lnRT						
L1.	-.0012396	.0072858	-0.17	0.867	-.0164374	.0139582
_cons	.8139791	.1629371	5.00	0.000	.4740983	1.15386

```
. xtscc lny L.lny L2.lny L.lnRT L2.lnRT, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       216
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,    19)     =   1513.88
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9758
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny						
L1.	.808948	.0700946	11.54	0.000	.6622383	.9556577
L2.	.1230457	.0801277	1.54	0.141	-.0446635	.290755
lnRT						
L1.	-.0520524	.0173872	-2.99	0.007	-.0884442	-.0156605
L2.	.0523271	.0127519	4.10	0.001	.0256371	.0790171
_cons	.7506341	.1421413	5.28	0.000	.453129	1.048139

```
. xtscc lny L.lny L2.lny L3.lny L.lnRT L2.lnRT L3.lnRT, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       205
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  6,     18)    =   1257.82
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9720
```

lny	Coef.	Drisc/Kraay Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny						
L1.	.765396	.1031743	7.42	0.000	.5486348	.9821572
L2.	.1164003	.1299777	0.90	0.382	-.1566728	.3894734
L3.	.0425788	.061549	0.69	0.498	-.0867308	.1718883
lnRT						
L1.	-.0460674	.0175002	-2.63	0.017	-.082834	-.0093007
L2.	.0251469	.0315191	0.80	0.435	-.0410723	.0913661
L3.	.0238934	.0338531	0.71	0.489	-.0472294	.0950162
_cons	.7869921	.1885998	4.17	0.001	.3907586	1.183226

A.5.6.2 Results of the Granger causality test

```
. xtscc lny L.lny L2.lny L.lnRT L2.lnRT, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       216
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,     19)    =   1513.88
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9758

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |    .808948   .0700946    11.54   0.000     .6622383    .9556577
         L2. |   .1230457   .0801277     1.54   0.141    -.0446635     .290755
             |
        lnRT |
         L1. |  -.0520524   .0173872    -2.99   0.007    -.0884442   -.0156605
         L2. |   .0523271   .0127519     4.10   0.001     .0256371    .0790171
             |
       _cons |   .7506341   .1421413     5.28   0.000      .453129    1.048139
------------------------------------------------------------------------------

. test L.lnRT

 ( 1)  L.lnRT = 0

       F(  1,    19) =    8.96
            Prob > F =    0.0075

. test L2.lnRT

 ( 1)  L2.lnRT = 0

       F(  1,    19) =   16.84
            Prob > F =    0.0006
```

```
. xtscc lnRT L.lnRT L2.lnRT L.lny L2.lny, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       216
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,     19)    =    230.22
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.8940

------------------------------------------------------------------------------
             |             Drisc/Kraay
        lnRT |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRT |
         L1. |   .9138779      .0821    11.13   0.000     .7420407    1.085715
         L2. |  -.0625971   .0825233    -0.76   0.457    -.2353204    .1101262
             |
         lny |
         L1. |   .3012427   .2114969     1.42   0.171    -.1414254    .7439107
         L2. |  -.1807621   .2105047    -0.86   0.401    -.6213535    .2598293
             |
       _cons |   1.394952   .5742011     2.43   0.025     .1931357    2.596769
------------------------------------------------------------------------------

. test L.lny

 ( 1)  L.lny = 0

       F(  1,    19) =    2.03
            Prob > F =    0.1706

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    19) =    0.74
            Prob > F =    0.4012

. xtscc lny L.lny L2.lny L.lnTEUp L2.lnTEUp, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       179
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,     23)    =    967.33
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9650

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |   .8364323   .0842598     9.93   0.000     .6621277    1.010737
         L2. |   .0983178   .0888541     1.11   0.280    -.0854909    .2821266
             |
      lnTEUp |
         L1. |   .0009126   .0042995     0.21   0.834    -.0079816    .0098068
         L2. |  -.0021083   .0042591    -0.50   0.625    -.0109189    .0067022
             |
       _cons |   .7345215   .1786642     4.11   0.000     .3649265    1.104117
------------------------------------------------------------------------------

. test L.lnTEUp

 ( 1)  L.lnTEUp = 0

       F(  1,    23) =    0.05
            Prob > F =    0.8338

. test L2.lnTEUp

 ( 1)  L2.lnTEUp = 0

       F(  1,    23) =    0.25
            Prob > F =    0.6253
```

```
. xtscc lnTEUp L.lnTEUp L2.lnTEUp L.lny L2.lny, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       178
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,    23)     =    370.31
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9269

------------------------------------------------------------------------------
             |             Drisc/Kraay
      lnTEUp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lnTEUp |
         L1. |    1.05435   .0505399    20.86   0.000     .9498005      1.1589
         L2. |  -.2110452   .0394311    -5.35   0.000    -.2926147   -.1294756
             |
         lny |
         L1. |  -.1729268    .749495    -0.23   0.820    -1.723375    1.377522
         L2. |   .2247379   .7412647     0.30   0.764    -1.308685    1.758161
             |
       _cons |   1.443029   2.080718     0.69   0.495    -2.861265    5.747323
------------------------------------------------------------------------------

. test L.lny

 ( 1)  L.lny = 0

       F(  1,    23) =    0.05
            Prob > F =    0.8196

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    23) =    0.09
            Prob > F =    0.7645
```

```
. xtscc lny L.lny L2.lny L.lnTEUr L2.lnTEUr, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       179
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,     23)    =   1095.24
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9655

------------------------------------------------------------------------------
             |             Drisc/Kraay
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |    .828379   .0779882    10.62   0.000     .6670482    .9897098
         L2. |   .1218343   .0812969     1.50   0.148    -.0463411    .2900097
             |
     lnTEUr  |
         L1. |   .0003946   .0036422     0.11   0.915    -.0071398     .007929
         L2. |  -.0036616   .0041029    -0.89   0.381     -.012149    .0048258
             |
       _cons |   .5957462   .1758803     3.39   0.003     .2319101    .9595824
------------------------------------------------------------------------------


. test L.lnTEUr

 ( 1)  L.lnTEUr = 0

       F(  1,    23) =    0.01
            Prob > F =    0.9147

. test L2.lnTEUr

 ( 1)  L2.lnTEUr = 0

       F(  1,    23) =    0.80
            Prob > F =    0.3814

. xtscc lnTEUr L.lnTEUr L2.lnTEUr L.lny L2.lny, fe

Regression with Driscoll-Kraay standard errors   Number of obs     =       178
Method: Fixed-effects regression                 Number of groups  =        11
Group variable (i): ID                           F(  4,     23)    =    815.15
maximum lag: 2                                   Prob > F          =    0.0000
                                                 within R-squared  =    0.9166

------------------------------------------------------------------------------
             |             Drisc/Kraay
      lnTEUr |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lnTEUr |
         L1. |   1.042257   .0662369    15.74   0.000     .9052353    1.179278
         L2. |  -.2103426   .0385117    -5.46   0.000    -.2900102    -.130675
             |
         lny |
         L1. |   .1508732   .6371127     0.24   0.815    -1.167095    1.468841
         L2. |   .4331949     .66515     0.65   0.521    -.9427728    1.809163
             |
       _cons |  -4.012396   3.307663    -1.21   0.237    -10.85482    2.830025
------------------------------------------------------------------------------


. test L.lny

 ( 1)  L.lny = 0

       F(  1,    23) =    0.06
            Prob > F =    0.8149

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    23) =    0.42
            Prob > F =    0.5213
```

Appendix 6 Application of econometric analysis by a region

A.6.1 Correlation analysis by a region

i) Seoul

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 1/26
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	-0.1419	1.0000								
ngd	0.4314	-0.1619	1.0000							
Sk	0.5441	0.1324	0.0562	1.0000						
Sh	0.9691	-0.0830	0.3033	0.5929	1.0000					
y L1.	0.9963	-0.1454	0.4426	0.5511	0.9720	1.0000				
rd	0.3264	0.0304	0.2952	-0.2480	0.2117	0.3110	1.0000			
RT	.	.	.	.	.	.	.	.		
TEUp	.	.	.	.	.	.	.	.	.	
TEUr	.	.	.	.	.	.	.	.	.	.

ii) Busan

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 27/52
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.7886	1.0000								
ngd	-0.0443	-0.4206	1.0000							
Sk	0.7369	0.4757	0.2081	1.0000						
Sh	0.9624	0.6704	0.0492	0.7520	1.0000					
y L1.	0.9879	0.7610	-0.0640	0.7471	0.9575	1.0000				
rd	0.9513	0.8844	-0.2138	0.6319	0.8932	0.9374	1.0000			
RT	0.9619	0.6920	0.0020	0.7598	0.9291	0.9594	0.9051	1.0000		
TEUp	0.9685	0.7246	-0.0360	0.7375	0.9260	0.9645	0.9209	0.9973	1.0000	
TEUr	0.9514	0.8515	-0.1983	0.6993	0.8995	0.9363	0.9637	0.9454	0.9563	1.0000

iii) Daegu

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 53/78
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.2724	1.0000								
ngd	-0.4519	0.0810	1.0000							
Sk	0.7692	0.4194	-0.1209	1.0000						
Sh	0.9769	0.1780	-0.3795	0.7605	1.0000					
y L1.	0.9825	0.2573	-0.4476	0.7547	0.9723	1.0000				
rd	0.9465	0.1531	-0.5755	0.5968	0.9156	0.9439	1.0000			
RT	.	.	.	.	.	.	.	.		
TEUp	.	.	.	.	.	.	.	.	.	
TEUr	.	.	.	.	.	.	.	.	.	.

iv) Incheon

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 79/104
(obs=21)
```

	y	yt	ngd	Sk	Sh	L.y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9830	1.0000								
ngd	-0.3578	-0.4128	1.0000							
Sk	0.6746	0.6461	0.0259	1.0000						
Sh	0.9684	0.9408	-0.2831	0.7008	1.0000					
y L1.	0.9650	0.9491	-0.4187	0.6192	0.9634	1.0000				
rd	0.6302	0.6331	-0.5185	0.3987	0.6596	0.7027	1.0000			
RT	0.8844	0.8462	-0.2844	0.8471	0.8555	0.8495	0.6157	1.0000		
TEUp	0.9461	0.9093	-0.2818	0.7673	0.9612	0.9436	0.7355	0.9196	1.0000	
TEUr	0.9461	0.9093	-0.2818	0.7673	0.9612	0.9436	0.7355	0.9196	1.0000	1.0000

v) Gwangju

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 105/130
(obs=21)
```

	y	yt	ngd	Sk	Sh	L.y	rd	RT	TEUp	TEUr
y	1.0000									
yt	-0.2583	1.0000								
ngd	-0.5741	0.3405	1.0000							
Sk	0.6544	0.1200	-0.3750	1.0000						
Sh	0.9579	-0.4367	-0.6661	0.6183	1.0000					
y L1.	0.9857	-0.2659	-0.5657	0.6553	0.9522	1.0000				
rd	0.8582	-0.2134	-0.5569	0.5643	0.8161	0.8641	1.0000			
RT	.	.	.	.	.	.	.	.		
TEUp	.	.	.	.	.	.	.	.	.	
TEUr	.	.	.	.	.	.	.	.	.	.

vi) Daejeon

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 131/156
(obs=21)
```

	y	yt	ngd	Sk	Sh	L.y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.8230	1.0000								
ngd	-0.7992	-0.5233	1.0000							
Sk	0.5455	0.6044	-0.4732	1.0000						
Sh	0.9406	0.6981	-0.9034	0.5634	1.0000					
y L1.	0.9701	0.8403	-0.8349	0.5230	0.9356	1.0000				
rd	0.7919	0.8212	-0.6263	0.5856	0.7331	0.8358	1.0000			
RT	.	.	.	.	.	.	.	.		
TEUp	.	.	.	.	.	.	.	.	.	
TEUr	.	.	.	.	.	.	.	.	.	.

vii) Ulsan

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 157/182
(obs=17)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	-0.4309	1.0000								
ngd	-0.4076	0.6009	1.0000							
Sk	0.5944	-0.0519	0.2421	1.0000						
Sh	0.9396	-0.3495	-0.3120	0.6400	1.0000					
y L1.	0.9500	-0.4826	-0.3518	0.6559	0.9160	1.0000				
rd	0.5228	0.2160	-0.1267	0.4099	0.6804	0.5493	1.0000			
RT	0.9228	-0.2186	-0.2093	0.7061	0.9427	0.8534	0.6029	1.0000		
TEUp	0.8522	-0.6181	-0.2816	0.6007	0.7633	0.9101	0.2915	0.7045	1.0000	
TEUr	0.8522	-0.6181	-0.2816	0.6007	0.7633	0.9101	0.2915	0.7045	1.0000	1.0000

viii) Gyeonggi

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 183/208
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9844	1.0000								
ngd	-0.8382	-0.8108	1.0000							
Sk	-0.4040	-0.4000	0.6371	1.0000						
Sh	0.9836	0.9756	-0.8892	-0.5079	1.0000					
y L1.	0.9929	0.9749	-0.8483	-0.3887	0.9780	1.0000				
rd	-0.1050	-0.0752	0.0243	-0.2159	-0.1018	-0.1424	1.0000			
RT	0.9353	0.9304	-0.7318	-0.2232	0.8976	0.9384	-0.0328	1.0000		
TEUp	0.9705	0.9473	-0.8427	-0.3236	0.9585	0.9741	-0.1703	0.9243	1.0000	
TEUr	0.9705	0.9473	-0.8427	-0.3236	0.9585	0.9741	-0.1703	0.9243	1.0000	1.0000

ix) Gangwon

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 209/234
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.8837	1.0000								
ngd	0.2826	0.3256	1.0000							
Sk	0.7195	0.7613	0.2208	1.0000						
Sh	0.9556	0.7907	0.0734	0.6332	1.0000					
y L1.	0.9828	0.8525	0.2799	0.6771	0.9401	1.0000				
rd	0.9276	0.7823	0.1347	0.5811	0.9274	0.9183	1.0000			
RT	0.9350	0.9001	0.2295	0.7966	0.8774	0.9308	0.7970	1.0000		
TEUp	0.5446	0.3442	-0.2274	0.3278	0.6656	0.5246	0.5193	0.4892	1.0000	
TEUr	0.5446	0.3442	-0.2274	0.3278	0.6656	0.5246	0.5193	0.4892	1.0000	1.0000

x) Chungbuk

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 235/260
(obs=21)
```

	y	yt	ngd	Sk	Sh	L.y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9702	1.0000								
ngd	-0.0788	-0.0079	1.0000							
Sk	0.5489	0.5595	-0.0084	1.0000						
Sh	0.9553	0.9235	0.0108	0.5321	1.0000					
y L1.	0.9888	0.9631	-0.0973	0.5405	0.9403	1.0000				
rd	0.8882	0.8232	-0.2857	0.3697	0.8785	0.8695	1.0000			
RT	.	.	.	.	.	.	.	.		
TEUp	.	.	.	.	.	.	.	.	.	
TEUr	.	.	.	.	.	.	.	.	.	.

xi) Chungnam

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 261/286
(obs=21)
```

	y	yt	ngd	Sk	Sh	L.y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9465	1.0000								
ngd	-0.0522	-0.0281	1.0000							
Sk	0.3184	0.2477	0.1634	1.0000						
Sh	0.9668	0.8860	0.0581	0.2696	1.0000					
y L1.	0.9939	0.9211	-0.1146	0.3063	0.9587	1.0000				
rd	0.7349	0.7404	0.0657	0.1495	0.7160	0.7010	1.0000			
RT	0.9255	0.9246	-0.1190	0.1717	0.8782	0.9269	0.6465	1.0000		
TEUp	0.8110	0.6908	-0.1204	0.3584	0.7907	0.8395	0.3020	0.7909	1.0000	
TEUr	0.8110	0.6908	-0.1204	0.3584	0.7907	0.8395	0.3020	0.7909	1.0000	1.0000

xii) Jeonbuk

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 287/312
(obs=21)
```

	y	yt	ngd	Sk	Sh	L.y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9312	1.0000								
ngd	0.0922	-0.0621	1.0000							
Sk	0.8438	0.7161	0.1737	1.0000						
Sh	0.9564	0.8316	0.2060	0.8382	1.0000					
y L1.	0.9895	0.9099	0.0999	0.8172	0.9584	1.0000				
rd	0.9452	0.8207	0.1162	0.8301	0.9425	0.9403	1.0000			
RT	0.9594	0.8859	-0.0022	0.7931	0.8959	0.9446	0.9261	1.0000		
TEUp	0.7613	0.7549	0.0940	0.5852	0.7003	0.7395	0.6719	0.8014	1.0000	
TEUr	0.7659	0.7614	0.0849	0.6001	0.7001	0.7415	0.6736	0.8073	0.9992	1.0000

xiii) Jeonnam

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 313/338
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9588	1.0000								
ngd	0.4064	0.5055	1.0000							
Sk	-0.0472	-0.0149	0.4271	1.0000						
Sh	0.9902	0.9515	0.4029	-0.0687	1.0000					
y L1.	0.9893	0.9530	0.4077	-0.0623	0.9899	1.0000				
rd	0.9624	0.9108	0.3670	-0.0062	0.9697	0.9713	1.0000			
RT	0.9708	0.9346	0.4229	0.0874	0.9648	0.9664	0.9544	1.0000		
TEUp	0.9748	0.9119	0.2234	-0.1345	0.9761	0.9669	0.9578	0.9461	1.0000	
TEUr	0.9748	0.9119	0.2234	-0.1345	0.9761	0.9669	0.9578	0.9461	1.0000	1.0000

xiv) Gyeongbuk

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 339/364
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9539	1.0000								
ngd	0.3541	0.3870	1.0000							
Sk	-0.8102	-0.7769	-0.4550	1.0000						
Sh	0.9550	0.9444	0.3396	-0.8303	1.0000					
y L1.	0.9934	0.9600	0.3609	-0.8225	0.9688	1.0000				
rd	0.9819	0.9276	0.2700	-0.7766	0.9570	0.9823	1.0000			
RT	0.9499	0.8988	0.3748	-0.7828	0.9034	0.9413	0.9069	1.0000		
TEUp	0.7106	0.8441	0.3093	-0.4972	0.6978	0.7364	0.6893	0.6526	1.0000	
TEUr	0.7106	0.8441	0.3093	-0.4972	0.6978	0.7364	0.6893	0.6526	1.0000	1.0000

xv) Gyeongnam

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 365/390
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.7643	1.0000								
ngd	0.2000	-0.1763	1.0000							
Sk	0.3396	0.6025	-0.0284	1.0000						
Sh	0.9098	0.6159	0.2857	0.2533	1.0000					
y L1.	0.9699	0.7098	0.2314	0.2453	0.9330	1.0000				
rd	0.8148	0.4577	0.5244	0.1191	0.8543	0.8357	1.0000			
RT	0.9282	0.7361	0.2545	0.2919	0.9046	0.9524	0.8615	1.0000		
TEUp	-0.5702	-0.5556	-0.1072	-0.3123	-0.4801	-0.5974	-0.3230	-0.5192	1.0000	
TEUr	0.7995	0.7492	0.1459	0.3553	0.7991	0.8488	0.6465	0.8997	-0.6984	1.0000

xvi) Jeju

```
. correlate y yt ngd Sk Sh L.y rd RT TEUp TEUr in 391/416
(obs=21)
```

	y	yt	ngd	Sk	Sh	L. y	rd	RT	TEUp	TEUr
y	1.0000									
yt	0.9203	1.0000								
ngd	0.4941	0.6296	1.0000							
Sk	0.8109	0.8425	0.4543	1.0000						
Sh	0.9460	0.9373	0.4766	0.8419	1.0000					
y L1.	0.9873	0.9297	0.5183	0.7942	0.9404	1.0000				
rd	0.7824	0.7743	0.4179	0.5736	0.7579	0.7892	1.0000			
RT	0.0063	0.2252	0.6228	0.0976	0.0071	0.0797	0.0051	1.0000		
TEUp	0.9213	0.9060	0.5570	0.7660	0.8630	0.9364	0.7112	0.1994	1.0000	
TEUr	0.9213	0.9060	0.5570	0.7660	0.8630	0.9364	0.7112	0.1994	1.0000	1.0000

A.6.2 Regression analysis by a region

i) Seoul

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 1/26
no observations
r(2000);
```

ii) Busan

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT  in 27/52
```

Source	SS	df	MS
Model	.629485597	6	.104914266
Residual	.008247907	13	.000634454
Total	.637733504	19	.033564921

Number of obs	=	20
F(6, 13)	=	165.36
Prob > F	=	0.0000
R-squared	=	0.9871
Adj R-squared	=	0.9811
Root MSE	=	.02519

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0015331	.0062922	-0.24	0.811	-.0151267	.0120605
lnSk	-.0022444	.0674428	-0.03	0.974	-.1479458	.1434569
lnSh	.1094363	.0736412	1.49	0.161	-.0496559	.2685285
lny						
L1.	.4666066	.1840361	2.54	0.025	.0690208	.8641923
lnrd	.1488813	.1189678	1.25	0.233	-.108133	.4058956
lnRT	.0682963	.0587105	1.16	0.266	-.05854	.1951326
_cons	3.489516	1.274764	2.74	0.017	.7355551	6.243476

iii) Daegu

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 53/78
no observations
r(2000);
```

iv) Incheon

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 79/104
```

Source	SS	df	MS
Model	.284076234	6	.047346039
Residual	.008324947	14	.000594639
Total	.29240118	20	.014620059

Number of obs	=	21
F(6, 14)	=	79.62
Prob > F	=	0.0000
R-squared	=	0.9715
Adj R-squared	=	0.9593
Root MSE	=	.02439

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0131296	.0150794	-0.87	0.399	-.0454717	.0192125
lnSk	-.0990916	.0948082	-1.05	0.314	-.302435	.1042517
lnSh	.2776481	.0947265	2.93	0.011	.0744799	.4808163
lny						
L1.	.2037743	.2243482	0.91	0.379	-.2774048	.6849534
lnrd	-.1278978	.1041472	-1.23	0.240	-.3512714	.0954758
lnRT	.2998404	.1358747	2.21	0.045	.0084182	.5912627
_cons	2.649658	2.001817	1.32	0.207	-1.643813	6.943128

v) Gwangju

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 105/130
no observations
r(2000);
```

vi) Daejeon

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 131/156
no observations
r(2000);
```

vii) Ulsan

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(6, 10)        =     57.71
       Model |  .113842033         6  .018973672   Prob > F        =    0.0000
    Residual |  .003287484        10  .000328748   R-squared       =    0.9719
-------------+----------------------------------   Adj R-squared   =    0.9551
       Total |  .117129517        16  .007320595   Root MSE        =    .01813

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0321414   .0353807    -0.91   0.385    -.1109745    .0466917
        lnSk |  -.0874784   .0755513    -1.16   0.274    -.2558172    .0808604
        lnSh |   .0355139   .0900617     0.39   0.702    -.1651562     .236184
             |
         lny |
         L1. |   .4253702   .1237945     3.44   0.006     .1495388    .7012015
             |
        lnrd |   -.094666   .0715977    -1.32   0.216    -.2541957    .0648637
        lnRT |   .4383841   .1514037     2.90   0.016     .1010357    .7757325
       _cons |  -1.252506   3.124455    -0.40   0.697    -8.214224    5.709213
------------------------------------------------------------------------------
```

viii) Gyeonggi

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 183/208

      Source |       SS           df       MS      Number of obs   =        21
-------------+----------------------------------   F(6, 14)        =    232.95
       Model |   .64915814         6  .108193023   Prob > F        =    0.0000
    Residual |  .006502167        14   .00046444   R-squared       =    0.9901
-------------+----------------------------------   Adj R-squared   =    0.9858
       Total |  .655660307        20  .032783015   Root MSE        =    .02155

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0323399   .0350616     0.92   0.372    -.0428598    .1075396
        lnSk |   .0541221   .0737154     0.73   0.475    -.1039817    .2122258
        lnSh |   .2372295   .0929995     2.55   0.023     .0377654    .4366936
             |
         lny |
         L1. |   .5787055   .2093468     2.76   0.015     .1297013     1.02771
             |
        lnrd |   .0635708   .0851291     0.75   0.468    -.1190131    .2461546
        lnRT |   .0351693    .047782     0.74   0.474     -.067313    .1376515
       _cons |   2.687398   1.556641     1.73   0.106    -.6512649    6.026061
------------------------------------------------------------------------------
```

ix) Gangwon

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 209/234
```

Source	SS	df	MS			
				Number of obs	=	21
				F(6, 14)	=	195.95
Model	.409032427	6	.068172071	Prob > F	=	0.0000
Residual	.004870769	14	.000347912	R-squared	=	0.9882
				Adj R-squared	=	0.9832
Total	.413903196	20	.02069516	Root MSE	=	.01865

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0227009	.0082729	2.74	0.016	.0049573	.0404444
lnSk	.070258	.0547355	1.28	0.220	-.0471379	.1876539
lnSh	.1419199	.0505596	2.81	0.014	.0334803	.2503594
lny						
L1.	.2831205	.1395404	2.03	0.062	-.0161638	.5824049
lnrd	.1083658	.0863335	1.26	0.230	-.0768011	.2935328
lnRT	.1776963	.1032828	1.72	0.107	-.0438233	.3992159
_cons	3.408596	1.208535	2.82	0.014	.8165469	6.000646

x) Chungbuk

```
.  reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 235/260
no observations
r(2000);
```

xi) Chungnam

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 261/286
```

Source	SS	df	MS			
				Number of obs	=	20
				F(6, 13)	=	440.84
Model	2.22098442	6	.37016407	Prob > F	=	0.0000
Residual	.010915925	13	.000839687	R-squared	=	0.9951
				Adj R-squared	=	0.9929
Total	2.23190035	19	.117468439	Root MSE	=	.02898

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0182204	.0176366	1.03	0.320	-.019881	.0563219
lnSk	.074385	.051044	1.46	0.169	-.0358889	.1846588
lnSh	.1245143	.1017021	1.22	0.243	-.0951998	.3442284
lny						
L1.	.6922147	.1581581	4.38	0.001	.3505348	1.033895
lnrd	.1011281	.068718	1.47	0.165	-.047328	.2495842
lnRT	.0547238	.0538727	1.02	0.328	-.0616612	.1711087
_cons	1.450795	.8401981	1.73	0.108	-.3643431	3.265932

xii) Jeonbuk

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT  in 287/312
```

Source	SS	df	MS
Model	.61461218	6	.102435363
Residual	.005073863	11	.00046126
Total	.619686044	17	.03645212

Number of obs	=	18
F(6, 11)	=	222.08
Prob > F	=	0.0000
R-squared	=	0.9918
Adj R-squared	=	0.9873
Root MSE	=	.02148

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0055907	.0108316	0.52	0.616	-.0182495	.0294309
lnSk	.0859706	.048659	1.77	0.105	-.0211271	.1930684
lnSh	.0986963	.069314	1.42	0.182	-.0538629	.2512554
lny						
L1.	.4706892	.125631	3.75	0.003	.1941772	.7472011
lnrd	-.0157141	.0886235	-0.18	0.862	-.2107732	.1793449
lnRT	.1962143	.0836842	2.34	0.039	.0120267	.3804019
_cons	1.868086	.784821	2.38	0.036	.1407063	3.595465

xiii) Jeonnam

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 313/338
```

Source	SS	df	MS
Model	1.10736148	6	.184560247
Residual	.011855084	8	.001481886
Total	1.11921656	14	.07994404

Number of obs	=	15
F(6, 8)	=	124.54
Prob > F	=	0.0000
R-squared	=	0.9894
Adj R-squared	=	0.9815
Root MSE	=	.0385

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0024564	.0158938	-0.15	0.881	-.0391076	.0341949
lnSk	-.0068543	.1022944	-0.07	0.948	-.2427457	.229037
lnSh	.102884	.1698387	0.61	0.561	-.2887648	.4945328
lny						
L1.	.5846288	.3118234	1.87	0.098	-.1344372	1.303695
lnrd	-.0775359	.2298729	-0.34	0.745	-.6076237	.4525519
lnRT	.2697992	.2039024	1.32	0.222	-.2004005	.7399989
_cons	-.5828884	2.898488	-0.20	0.846	-7.266813	6.101036

xiv) Gyeongbuk

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 339/364
```

Source	SS	df	MS
Model	1.14927968	6	.191546614
Residual	.012876169	12	.001073014
Total	1.16215585	18	.064564214

Number of obs	=	19
F(6, 12)	=	178.51
Prob > F	=	0.0000
R-squared	=	0.9889
Adj R-squared	=	0.9834
Root MSE	=	.03276

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0003599	.0093765	0.04	0.970	-.0200698	.0207895
lnSk	.0078018	.0964475	0.08	0.937	-.2023393	.2179429
lnSh	-.1235486	.1155687	-1.07	0.306	-.3753512	.128254
lny						
L1.	.6554671	.2749355	2.38	0.035	.056434	1.2545
lnrd	.3559663	.2423072	1.47	0.168	-.1719758	.8839084
lnRT	.320924	.2108229	1.52	0.154	-.1384196	.7802675
_cons	-3.117108	2.729714	-1.14	0.276	-9.064643	2.830427

xv) Gyeongnam

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 365/390
```

Source	SS	df	MS
Model	.542821999	6	.090470333
Residual	.030436658	13	.002341281
Total	.573258657	19	.030171508

Number of obs	=	20
F(6, 13)	=	38.64
Prob > F	=	0.0000
R-squared	=	0.9469
Adj R-squared	=	0.9224
Root MSE	=	.04839

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0113096	.059157	0.19	0.851	-.1164912	.1391105
lnSk	.2884119	.1285848	2.24	0.043	.0106214	.5662024
lnSh	.0760128	.1476839	0.51	0.615	-.2430388	.3950644
lny						
L1.	.5942934	.3201011	1.86	0.086	-.0972429	1.28583
lnrd	.0591223	.208973	0.28	0.782	-.3923364	.5105811
lnRT	.0808732	.1576267	0.51	0.617	-.2596586	.4214051
_cons	1.691626	1.72803	0.98	0.345	-2.041555	5.424807

xvi) Jeju

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 391/416
```

Source	SS	df	MS
Model	.478558024	6	.079759671
Residual	.008549188	14	.000610656
Total	.487107211	20	.024355361

Number of obs	=	21
F(6, 14)	=	130.61
Prob > F	=	0.0000
R-squared	=	0.9824
Adj R-squared	=	0.9749
Root MSE	=	.02471

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	.0321985	.0244075	1.32	0.208	-.0201505	.0845474
lnSk	.0728424	.0614202	1.19	0.255	-.0588908	.2045756
lnSh	.0405545	.0897833	0.45	0.658	-.1520114	.2331205
lny						
L1.	.7938599	.1038211	7.65	0.000	.5711858	1.016534
lnrd	.0101621	.0427734	0.24	0.816	-.0815777	.1019018
lnRT	-.0878011	.041214	-2.13	0.051	-.1761963	.000594
_cons	3.117693	.98465	3.17	0.007	1.005829	5.229557

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(6, 13)        =    165.36
       Model |  .629485597         6  .104914266   Prob > F        =    0.0000
    Residual |  .008247907        13  .000634454   R-squared       =    0.9871
-------------+----------------------------------   Adj R-squared   =    0.9811
       Total |  .637733504        19  .033564921   Root MSE        =    .02519

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0015331   .0062922    -0.24   0.811    -.0151267    .0120605
        lnSk |  -.0022444   .0674428    -0.03   0.974    -.1479458    .1434569
        lnSh |   .1094363   .0736412     1.49   0.161    -.0496559    .2685285
             |
         lny |
         L1. |   .4666066   .1840361     2.54   0.025     .0690208    .8641923
             |
        lnrd |   .1488813   .1189678     1.25   0.233     -.108133    .4058956
        lnRT |   .0682963   .0587105     1.16   0.266      -.05854    .1951326
       _cons |   3.489516   1.274764     2.74   0.017     .7355551    6.243476
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT CE in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(7, 12)        =    178.85
       Model |  .631678934         7  .090239848   Prob > F        =    0.0000
    Residual |   .00605457        12  .000504547   R-squared       =    0.9905
-------------+----------------------------------   Adj R-squared   =    0.9850
       Total |  .637733504        19  .033564921   Root MSE        =    .02246

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0016919   .0058205     0.29   0.776    -.0109899    .0143736
        lnSk |   .0261188   .0616625     0.42   0.679    -.1082322    .1604698
        lnSh |    .158478    .069756     2.27   0.042     .0064926    .3104633
             |
         lny |
         L1. |   .4339975   .1648606     2.63   0.022     .0747971    .7931979
             |
        lnrd |   .1673659   .1064612     1.57   0.142    -.0645931     .399325
        lnRT |    .047399   .0533067     0.89   0.391    -.0687465    .1635444
          CE |   .0000663   .0000318     2.08   0.059    -2.98e-06    .0001356
       _cons |   3.951922   1.158223     3.41   0.005     1.428372    6.475473
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT IM in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(7, 12)        =    182.04
       Model |  .631784102         7  .090254872   Prob > F        =    0.0000
    Residual |  .005949401        12  .000495783   R-squared       =    0.9907
-------------+----------------------------------   Adj R-squared   =    0.9852
       Total |  .637733504        19  .033564921   Root MSE        =    .02227

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0098519   .0067724    -1.45   0.171    -.0246077    .0049039
        lnSk |   -.042502   .0624816    -0.68   0.509    -.1786376    .0936337
        lnSh |   .1503957   .0678204     2.22   0.047     .0026278    .2981637
             |
         lny |
         L1. |   .5639425   .1688495     3.34   0.006     .1960511    .9318339
             |
        lnrd |   .0557801    .113708     0.49   0.633    -.1919685    .3035286
        lnRT |   .0555248   .0522372     1.06   0.309    -.0582901    .1693398
          IM |   .0001693   .0000786     2.15   0.052    -2.02e-06    .0003406
       _cons |    2.96772   1.152638     2.57   0.024     .4563365    5.479103
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 79/104

      Source |       SS           df       MS      Number of obs   =        21
-------------+----------------------------------   F(6, 14)        =     79.62
       Model |  .284076234         6  .047346039   Prob > F        =    0.0000
    Residual |  .008324947        14  .000594639   R-squared       =    0.9715
-------------+----------------------------------   Adj R-squared   =    0.9593
       Total |   .29240118        20  .014620059   Root MSE        =    .02439

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0131296   .0150794    -0.87   0.399    -.0454717    .0192125
        lnSk |  -.0990916   .0948082    -1.05   0.314     -.302435    .1042517
        lnSh |   .2776481   .0947265     2.93   0.011     .0744799    .4808163
             |
         lny |
         L1. |   .2037743   .2243482     0.91   0.379    -.2774048    .6849534
             |
        lnrd |  -.1278978   .1041472    -1.23   0.240    -.3512714    .0954758
        lnRT |   .2998404   .1358747     2.21   0.045     .0084182    .5912627
       _cons |   2.649658   2.001817     1.32   0.207    -1.643813    6.943128
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT CE in 79/104

      Source |       SS           df       MS      Number of obs   =        21
-------------+----------------------------------   F(7, 13)        =     82.56
       Model |  .285968387         7  .040852627   Prob > F        =    0.0000
    Residual |  .006432793        13   .00049483   R-squared       =    0.9780
-------------+----------------------------------   Adj R-squared   =    0.9662
       Total |   .29240118        20  .014620059   Root MSE        =    .02224

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0030333   .0160481     0.19   0.853    -.0316365     .037703
        lnSk |  -.1266458   .0876267    -1.45   0.172    -.3159517    .0626601
        lnSh |   .2899201   .0866394     3.35   0.005      .102747    .4770931
             |
         lny |
         L1. |   .2469145   .2058414     1.20   0.252    -.1977789    .6916079
             |
        lnrd |  -.1551578   .0960229    -1.62   0.130    -.3626027    .0522871
        lnRT |   .3019642   .1239529     2.44   0.030     .0341802    .5697481
          CE |   .0000362   .0000185     1.96   0.072    -3.79e-06    .0000762
       _cons |    2.26242   1.836811     1.23   0.240    -1.705769    6.230609
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT IM in 79/104

      Source |       SS           df       MS      Number of obs   =        21
-------------+----------------------------------   F(7, 13)        =     76.84
       Model |   .28550084         7  .040785834   Prob > F        =    0.0000
    Residual |   .00690034        13  .000530795   R-squared       =    0.9764
-------------+----------------------------------   Adj R-squared   =    0.9637
       Total |   .29240118        20  .014620059   Root MSE        =    .02304

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0227219   .0154032    -1.48   0.164    -.0559985    .0105546
        lnSk |  -.0464274   .0951678    -0.49   0.634     -.252025    .1591702
        lnSh |   .2248774   .0951172     2.36   0.034     .0193891    .4303657
             |
         lny |
         L1. |    .373596   .2359523     1.58   0.137     -.136148      .88334
             |
        lnrd |  -.1641188    .100851    -1.63   0.128    -.3819941    .0537565
        lnRT |   .1962402   .1431041     1.37   0.193    -.1129174    .5053978
          IM |   .0000881   .0000538     1.64   0.125    -.0000281    .0002043
       _cons |   2.920662   1.898524     1.54   0.148    -1.180849    7.022174
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(6, 10)        =     57.71
       Model |  .113842033         6  .018973672   Prob > F        =    0.0000
    Residual |  .003287484        10  .000328748   R-squared       =    0.9719
-------------+----------------------------------   Adj R-squared   =    0.9551
       Total |  .117129517        16  .007320595   Root MSE        =    .01813

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0321414   .0353807    -0.91   0.385    -.1109745    .0466917
        lnSk |  -.0874784   .0755513    -1.16   0.274    -.2558172    .0808604
        lnSh |   .0355139   .0900617     0.39   0.702    -.1651562     .236184
             |
         lny |
         L1. |   .4253702   .1237945     3.44   0.006     .1495388    .7012015
             |
        lnrd |   -.094666   .0715977    -1.32   0.216    -.2541957    .0648637
        lnRT |   .4383841   .1514037     2.90   0.016     .1010357    .7757325
       _cons |  -1.252506   3.124455    -0.40   0.697    -8.214224    5.709213
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT CE in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(7, 9)         =     44.54
       Model |  .113843516         7  .016263359   Prob > F        =    0.0000
    Residual |  .003286001         9  .000365111   R-squared       =    0.9719
-------------+----------------------------------   Adj R-squared   =    0.9501
       Total |  .117129517        16  .007320595   Root MSE        =    .01911

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0320548   .0373108    -0.86   0.413    -.1164578    .0523481
        lnSk |  -.0852598   .0868958    -0.98   0.352    -.2818318    .1113122
        lnSh |   .0383914   .1051013     0.37   0.723    -.1993643    .2761471
             |
         lny |
         L1. |   .4237581   .1328903     3.19   0.011     .1231395    .7243768
             |
        lnrd |   -.092985   .0799295    -1.16   0.275    -.2737982    .0878282
        lnRT |   .4290625   .2164393     1.98   0.079    -.0605572    .9186821
          CE |   2.45e-06   .0000385     0.06   0.951    -.0000846    .0000896
       _cons |  -1.077707   4.285158    -0.25   0.807    -10.77141    8.615994
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT IM in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(7, 9)         =     46.08
       Model |  .113949993         7   .01627857   Prob > F        =    0.0000
    Residual |  .003179524         9   .00035328   R-squared       =    0.9729
-------------+----------------------------------   Adj R-squared   =    0.9517
       Total |  .117129517        16  .007320595   Root MSE        =     .0188

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0497039   .0485234    -1.02   0.332    -.1594715    .0600637
        lnSk |  -.0771508   .0805169    -0.96   0.363    -.2592926     .104991
        lnSh |   .0320018   .0935775     0.34   0.740    -.1796852    .2436889
             |
         lny |
         L1. |   .4242605    .128346     3.31   0.009     .1339216    .7145994
             |
        lnrd |  -.1100958   .0792959    -1.39   0.198    -.2894757     .069284
        lnRT |   .4428368   .1571576     2.82   0.020     .0873215     .798352
          IM |   .0000453   .0000819     0.55   0.594    -.0001401    .0002307
       _cons |   -1.28179   3.239368    -0.40   0.702    -8.609749    6.046169
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 313/338

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(6, 8)         =    124.54
       Model |  1.10736148         6  .184560247   Prob > F        =    0.0000
    Residual |  .011855084         8  .001481886   R-squared       =    0.9894
-------------+----------------------------------   Adj R-squared   =    0.9815
       Total |  1.11921656        14   .07994404   Root MSE        =     .0385

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0024564   .0158938    -0.15   0.881    -.0391076    .0341949
        lnSk |  -.0068543   .1022944    -0.07   0.948    -.2427457     .229037
        lnSh |    .102884   .1698387     0.61   0.561    -.2887648    .4945328
             |
         lny |
         L1. |   .5846288   .3118234     1.87   0.098    -.1344372    1.303695
             |
        lnrd |  -.0775359   .2298729    -0.34   0.745    -.6076237    .4525519
        lnRT |   .2697992   .2039024     1.32   0.222    -.2004005    .7399989
       _cons |  -.5828884   2.898488    -0.20   0.846    -7.266813    6.101036
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT CE in 313/338

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(7, 7)         =     96.90
       Model |  1.10778454         7  .158254935   Prob > F        =    0.0000
    Residual |  .011432022         7  .001633146   R-squared       =    0.9898
-------------+----------------------------------   Adj R-squared   =    0.9796
       Total |  1.11921656        14   .07994404   Root MSE        =    .04041

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0010217   .0180304     0.06   0.956    -.0416135    .0436568
        lnSk |  -.0025261   .1077245    -0.02   0.982    -.2572541    .2522019
        lnSh |   .0864129   .1812092     0.48   0.648    -.3420788    .5149047
             |
         lny |
         L1. |   .6831636   .3803141     1.80   0.116    -.2161363    1.582464
             |
        lnrd |  -.1161386   .2529579    -0.46   0.660     -.714289    .4820119
        lnRT |   .2320919   .2265143     1.02   0.340    -.3035292     .767713
          CE |   .0000813   .0001598     0.51   0.626    -.0002965    .0004591
       _cons |   -.731022    3.05671    -0.24   0.818    -7.958993    6.496949
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh L.lny lnrd lnRT IM in 313/338

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(7, 7)         =    148.19
       Model |  1.11171469         7  .158816384   Prob > F        =    0.0000
    Residual |  .007501878         7  .001071697   R-squared       =    0.9933
-------------+----------------------------------   Adj R-squared   =    0.9866
       Total |  1.11921656        14   .07994404   Root MSE        =    .03274

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0029829   .0135188    -0.22   0.832    -.0349498     .028984
        lnSk |   .0095988   .0873745     0.11   0.916     -.197009    .2162066
        lnSh |  -.0369129    .160225    -0.23   0.824    -.4157847    .3419589
             |
         lny |
         L1. |   1.004776   .3373082     2.98   0.021     .2071685    1.802383
             |
        lnrd |  -.0713556   .1955104    -0.36   0.726    -.5336642     .390953
        lnRT |   .0613378   .2019061     0.30   0.770    -.4160944    .5387699
          IM |   .0003867   .0001919     2.02   0.084     -.000067    .0008404
       _cons |  -.8359572   2.468101    -0.34   0.745    -6.672088    5.000174
------------------------------------------------------------------------------
```

A.6.3 Post-estimation tests

A.6.3.1Tests for variables

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(6, 13)        =    165.36
       Model |  .629485597         6  .104914266   Prob > F        =    0.0000
    Residual |  .008247907        13  .000634454   R-squared       =    0.9871
-------------+----------------------------------   Adj R-squared   =    0.9811
       Total |  .637733504        19  .033564921   Root MSE        =    .02519

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0015331   .0062922    -0.24   0.811    -.0151267    .0120605
        lnSk |  -.0022444   .0674428    -0.03   0.974    -.1479458    .1434569
        lnSh |   .1094363   .0736412     1.49   0.161    -.0496559    .2685285
             |
         lny |
         L1. |   .4666066   .1840361     2.54   0.025     .0690208    .8641923
             |
        lnrd |   .1488813   .1189678     1.25   0.233     -.108133    .4058956
        lnRT |   .0682963   .0587105     1.16   0.266      -.05854    .1951326
       _cons |   3.489516   1.274764     2.74   0.017     .7355551    6.243476
------------------------------------------------------------------------------

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
         lny |
         L1. |     38.44    0.026011
        lnRT |     22.64    0.044161
        lnrd |     18.37    0.054446
        lnSh |     13.47    0.074217
        lnSk |      2.75    0.363720
       lnngd |      1.74    0.573220
-------------+----------------------
    Mean VIF |     16.24
```

A.6.3.2 Tests for residuals

```
. reg ehatbusan L.ehatbusan

      Source |       SS           df       MS      Number of obs   =        18
-------------+----------------------------------   F(1, 16)        =      1.57
       Model |  .001052399         1  .001052399   Prob > F        =    0.2283
    Residual |  .010729054        16  .000670566   R-squared       =    0.0893
-------------+----------------------------------   Adj R-squared   =    0.0324
       Total |  .011781453        17  .000693027   Root MSE        =     .0259

------------------------------------------------------------------------------
   ehatbusan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   ehatbusan |
         L1. |   .3024182   .2414006     1.25   0.228    -.2093283    .8141646
             |
       _cons |   .0009894   .0061107     0.16   0.873    -.0119648    .0139436
------------------------------------------------------------------------------

. reg ehatincheon L.ehatincheon

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(1, 18)        =      2.37
       Model |   .00102534         1   .00102534   Prob > F        =    0.1408
    Residual |  .007774894        18  .000431939   R-squared       =    0.1165
-------------+----------------------------------   Adj R-squared   =    0.0674
       Total |  .008800234        19   .00046317   Root MSE        =    .02078

------------------------------------------------------------------------------
 ehatincheon |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 ehatincheon |
         L1. |  -.3570261   .2317272    -1.54   0.141    -.8438668    .1298147
             |
       _cons |   .0002931   .0046579     0.06   0.951    -.0094927    .0100789
------------------------------------------------------------------------------

. reg ehatulsan L.ehatulsan

      Source |       SS           df       MS      Number of obs   =        16
-------------+----------------------------------   F(1, 14)        =      0.08
       Model |  .000017085         1  .000017085   Prob > F        =    0.7808
    Residual |   .00297088        14  .000212206   R-squared       =    0.0057
-------------+----------------------------------   Adj R-squared   =   -0.0653
       Total |  .002987966        15  .000199198   Root MSE        =    .01457

------------------------------------------------------------------------------
   ehatulsan |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   ehatulsan |
         L1. |  -.0730385   .2574048    -0.28   0.781    -.6251168    .4790399
             |
       _cons |  -.0010086   .0036447    -0.28   0.786    -.0088256    .0068084
------------------------------------------------------------------------------

. reg ehatjeonnam L.ehatjeonnam

      Source |       SS           df       MS      Number of obs   =        12
-------------+----------------------------------   F(1, 10)        =      1.79
       Model |  .003741875         1  .003741875   Prob > F        =    0.2104
    Residual |  .020884454        10  .002088445   R-squared       =    0.1519
-------------+----------------------------------   Adj R-squared   =    0.0671
       Total |   .02462633        11  .002238757   Root MSE        =     .0457

------------------------------------------------------------------------------
 ehatjeonnam |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 ehatjeonnam |
         L1. |   .4339062   .3241625     1.34   0.210    -.2883728    1.156185
             |
       _cons |  -.0020194   .0133406    -0.15   0.883     -.031744    .0277053
------------------------------------------------------------------------------
```

A.6.3.1.3 Parameter estimation

```
. reg lny lnngd lnSk lnSh lnrd lnRT in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(5, 14)        =    142.06
       Model |  .625407137         5  .125081427   Prob > F        =    0.0000
    Residual |  .012326367        14  .000880455   R-squared       =    0.9807
-------------+----------------------------------   Adj R-squared   =    0.9738
       Total |  .637733504        19  .033564921   Root MSE        =    .02967

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0045193   .0068583     0.66   0.521    -.0101902    .0192288
        lnSk |    .031524   .0778845     0.40   0.692    -.1355216    .1985696
        lnSh |    .190245   .0782051     2.43   0.029     .0225119    .3579782
        lnrd |   .3130797   .1175617     2.66   0.019     .0609351    .5652244
        lnRT |    .134788   .0618788     2.18   0.047     .0020713    .2675048
       _cons |   6.246621   .7836253     7.97   0.000     4.565912     7.92733
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh lnrd lnRT CE in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(6, 13)        =    142.50
       Model |   .62818236         6   .10469706   Prob > F        =    0.0000
    Residual |  .009551144        13  .000734703   R-squared       =    0.9850
-------------+----------------------------------   Adj R-squared   =    0.9781
       Total |  .637733504        19  .033564921   Root MSE        =    .02711

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0076569   .0064696     1.18   0.258    -.0063198    .0216336
        lnSk |    .060642   .0727068     0.83   0.419    -.0964315    .2177155
        lnSh |   .2388372    .075688     3.16   0.008     .0753232    .4023511
        lnrd |   .3209289    .107467     2.99   0.011     .0887606    .5530972
        lnRT |   .1061842     .05841     1.82   0.092     -.020003    .2323713
          CE |   .0000742   .0000382     1.94   0.074    -8.28e-06    .0001568
       _cons |   6.548654   .7325063     8.94   0.000     4.966171    8.131138
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnSh lnrd lnRT IM in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(6, 13)        =    118.20
       Model |   .62625363         6  .104375605   Prob > F        =    0.0000
    Residual |  .011479874        13  .000883067   R-squared       =    0.9820
-------------+----------------------------------   Adj R-squared   =    0.9737
       Total |  .637733504        19  .033564921   Root MSE        =    .02972

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |   .0003935   .0080581     0.05   0.962     -.017015     .017802
        lnSk |   .0121039   .0804824     0.15   0.883    -.1617678    .1859757
        lnSh |   .2240507   .0855943     2.62   0.021     .0391356    .4089659
        lnrd |   .2786705   .1228695     2.27   0.041     .0132271    .5441138
        lnRT |   .1354306    .061974     2.19   0.048      .001544    .2693172
          IM |    .000099   .0001011     0.98   0.345    -.0001194    .0003174
       _cons |   6.277813   .7854334     7.99   0.000     4.580987    7.974639
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh lnrd lnRT in 79/104
```

Source	SS	df	MS
Model	.283585657	5	.056717131
Residual	.008815523	15	.000587702
Total	.29240118	20	.014620059

Number of obs	=	21
F(5, 15)	=	96.51
Prob > F	=	0.0000
R-squared	=	0.9699
Adj R-squared	=	0.9598
Root MSE	=	.02424

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0159694	.0146654	-1.09	0.293	-.047228	.0152892
lnSk	-.1409038	.0823975	-1.71	0.108	-.3165299	.0347222
lnSh	.3562991	.0381806	9.33	0.000	.2749191	.437679
lnrd	-.1027386	.0998088	-1.03	0.320	-.3154761	.1099988
lnRT	.366259	.1138497	3.22	0.006	.1235941	.6089238
_cons	3.369642	1.827434	1.84	0.085	-.5254405	7.264724

```
. reg lny lnngd lnSk lnSh lnrd lnRT CE in 79/104
```

Source	SS	df	MS
Model	.285256381	6	.04754273
Residual	.0071448	14	.000510343
Total	.29240118	20	.014620059

Number of obs	=	21
F(6, 14)	=	93.16
Prob > F	=	0.0000
R-squared	=	0.9756
Adj R-squared	=	0.9651
Root MSE	=	.02259

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0014308	.0158534	-0.09	0.929	-.035433	.0325713
lnSk	-.1749163	.0790509	-2.21	0.044	-.3444636	-.005369
lnSh	.3833203	.0385863	9.93	0.000	.3005609	.4660798
lnrd	-.1232303	.0936953	-1.32	0.210	-.3241866	.0777261
lnRT	.3813798	.1064211	3.58	0.003	.1531293	.6096302
CE	.0000338	.0000187	1.81	0.092	-6.27e-06	.0000739
_cons	3.150267	1.707231	1.85	0.086	-.5113787	6.811912

```
. reg lny lnngd lnSk lnSh lnrd lnRT IM in 79/104
```

Source	SS	df	MS
Model	.284170131	6	.047361689
Residual	.008231049	14	.000587932
Total	.29240118	20	.014620059

Number of obs	=	21
F(6, 14)	=	80.56
Prob > F	=	0.0000
R-squared	=	0.9719
Adj R-squared	=	0.9598
Root MSE	=	.02425

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnngd	-.0228506	.0162108	-1.41	0.180	-.0576193	.0119181
lnSk	-.1306509	.0830527	-1.57	0.138	-.3087813	.0474794
lnSh	.3636501	.0388932	9.35	0.000	.2802324	.4470678
lnrd	-.1115157	.1002158	-1.11	0.285	-.3264571	.1034258
lnRT	.3384969	.1172268	2.89	0.012	.0870704	.5899234
IM	.0000507	.0000508	1.00	0.336	-.0000583	.0001597
_cons	3.870831	1.895653	2.04	0.060	-.1949401	7.936602

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(6, 10)        =     57.71
       Model |  .113842033         6  .018973672   Prob > F        =    0.0000
    Residual |  .003287484        10  .000328748   R-squared       =    0.9719
-------------+----------------------------------   Adj R-squared   =    0.9551
       Total |  .117129517        16  .007320595   Root MSE        =    .01813

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0321414   .0353807    -0.91   0.385    -.1109745    .0466917
        lnSk |  -.0874784   .0755513    -1.16   0.274    -.2558172    .0808604
        lnSh |   .0355139   .0900617     0.39   0.702    -.1651562     .236184
             |
         lny |
         L1. |   .4253702   .1237945     3.44   0.006     .1495388    .7012015
             |
        lnrd |   -.094666   .0715977    -1.32   0.216    -.2541957    .0648637
        lnRT |   .4383841   .1514037     2.90   0.016     .1010357    .7757325
       _cons |  -1.252506   3.124455    -0.40   0.697    -8.214224    5.709213
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT CE in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(7, 9)         =     44.54
       Model |  .113843516         7  .016263359   Prob > F        =    0.0000
    Residual |  .003286001         9  .000365111   R-squared       =    0.9719
-------------+----------------------------------   Adj R-squared   =    0.9501
       Total |  .117129517        16  .007320595   Root MSE        =    .01911

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0320548   .0373108    -0.86   0.413    -.1164578    .0523481
        lnSk |  -.0852598   .0868958    -0.98   0.352    -.2818318    .1113122
        lnSh |   .0383914   .1051013     0.37   0.723    -.1993643    .2761471
             |
         lny |
         L1. |   .4237581   .1328903     3.19   0.011     .1231395    .7243768
             |
        lnrd |   -.092985   .0799295    -1.16   0.275    -.2737982    .0878282
        lnRT |   .4290625   .2164393     1.98   0.079    -.0605572    .9186821
          CE |   2.45e-06   .0000385     0.06   0.951    -.0000846    .0000896
       _cons |  -1.077707   4.285158    -0.25   0.807    -10.77141    8.615994
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnSh L.lny lnrd lnRT IM in 157/182

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(7, 9)         =     46.08
       Model |  .113949993         7   .01627857   Prob > F        =    0.0000
    Residual |  .003179524         9   .00035328   R-squared       =    0.9729
-------------+----------------------------------   Adj R-squared   =    0.9517
       Total |  .117129517        16  .007320595   Root MSE        =     .0188

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0497039   .0485234    -1.02   0.332    -.1594715    .0600637
        lnSk |  -.0771508   .0805169    -0.96   0.363    -.2592926     .104991
        lnSh |   .0320018   .0935775     0.34   0.740    -.1796852    .2436889
             |
         lny |
         L1. |   .4242605    .128346     3.31   0.009     .1339216    .7145994
             |
        lnrd |  -.1100958   .0792959    -1.39   0.198    -.2894757     .069284
        lnRT |   .4428368   .1571576     2.82   0.020     .0873215     .798352
          IM |   .0000453   .0000819     0.55   0.594    -.0001401    .0002307
       _cons |   -1.28179   3.239368    -0.40   0.702    -8.609749    6.046169
------------------------------------------------------------------------------
```

```
. reg lny lnngd lnSk lnrd lnRT in 313/338

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(4, 10)        =    134.51
       Model |  1.09879396         4  .274698491   Prob > F        =    0.0000
    Residual |  .020422599        10   .00204226   R-squared       =    0.9818
-------------+----------------------------------   Adj R-squared   =    0.9745
       Total |  1.11921656        14   .07994404   Root MSE        =    .04519

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0029353   .0183549    -0.16   0.876    -.0438324    .0379619
        lnSk |  -.1974482   .0715271    -2.76   0.020    -.3568206   -.0380758
        lnrd |   .3134197   .1828533     1.71   0.117     -.094003    .7208423
        lnRT |   .6106937   .1719158     3.55   0.005     .2276415     .993746
       _cons |  -1.638652   2.486883    -0.66   0.525    -7.179772    3.902469
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnrd lnRT CE in 313/338

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(5, 9)         =     99.31
       Model |  1.09929194         5  .219858387   Prob > F        =    0.0000
    Residual |  .019924627         9  .002213847   R-squared       =    0.9822
-------------+----------------------------------   Adj R-squared   =    0.9723
       Total |  1.11921656        14   .07994404   Root MSE        =    .04705

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0065799   .0205976    -0.32   0.757    -.0531749    .0400151
        lnSk |  -.1850653   .0789156    -2.35   0.044    -.3635849   -.0065457
        lnrd |   .3160313   .1904596     1.66   0.131    -.1148182    .7468808
        lnRT |   .6112176   .1789956     3.41   0.008     .2063014    1.016134
          CE |  -.0000758   .0001599    -0.47   0.647    -.0004374    .0002858
       _cons |  -1.696566   2.592126    -0.65   0.529    -7.560363    4.167231
------------------------------------------------------------------------------

. reg lny lnngd lnSk lnrd lnRT IM in 313/338

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(5, 9)         =     97.95
       Model |  1.09901997         5  .219803994   Prob > F        =    0.0000
    Residual |  .020196594         9  .002244066   R-squared       =    0.9820
-------------+----------------------------------   Adj R-squared   =    0.9719
       Total |  1.11921656        14   .07994404   Root MSE        =    .04737

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnngd |  -.0025154   .0192858    -0.13   0.899    -.0461429     .041112
        lnSk |  -.2025555   .0766856    -2.64   0.027    -.3760304   -.0290806
        lnrd |   .3306222   .1991924     1.66   0.131    -.1199823    .7812267
        lnRT |   .5943898   .1873897     3.17   0.011     .1704848    1.018295
          IM |   .0000686   .0002163     0.32   0.758    -.0004206    .0005579
       _cons |  -1.382697   2.728775    -0.51   0.625    -7.555614     4.79022
------------------------------------------------------------------------------
```

A.6.3.2 Test of the causality

A.6.3.2.1 Test for the fit of lags

```
. reg lny L.lny L.lnRT  in 27/52
```

Source	SS	df	MS
Model	.633795555	2	.316897778
Residual	.014683859	18	.00081577
Total	.648479415	20	.032423971

Number of obs	=	21
F(2, 18)	=	388.46
Prob > F	=	0.0000
R-squared	=	0.9774
Adj R-squared	=	0.9748
Root MSE	=	.02856

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny						
L1.	.7952096	.1514269	5.25	0.000	.4770735	1.113346
lnRT						
L1.	.0577816	.0615053	0.94	0.360	-.0714361	.1869994
_cons	1.045952	.4967707	2.11	0.050	.0022757	2.089629

```
. reg lny L.lny L2.lny L.lnRT L2.lnRT in 27/52
```

Source	SS	df	MS
Model	.530550047	4	.132637512
Residual	.010398434	15	.000693229
Total	.540948481	19	.028470973

Number of obs	=	20
F(4, 15)	=	191.33
Prob > F	=	0.0000
R-squared	=	0.9808
Adj R-squared	=	0.9757
Root MSE	=	.02633

lny	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lny						
L1.	.6078758	.2318829	2.62	0.019	.1136291	1.102123
L2.	.1344811	.2292452	0.59	0.566	-.3541434	.6231055
lnRT						
L1.	-.1003009	.0883723	-1.13	0.274	-.2886621	.0880602
L2.	.1755116	.0881859	1.99	0.065	-.0124522	.3634754
_cons	1.277036	.527348	2.42	0.029	.1530201	2.401051

```
. reg lny L.lny L2.lny L3.lny L.lnRT L2.lnRT L3.lnRT in 27/52

      Source |       SS           df       MS      Number of obs   =        19
-------------+----------------------------------   F(6, 12)        =     91.90
       Model |  .435456976         6  .072576163   Prob > F        =    0.0000
    Residual |  .009476685        12  .000789724   R-squared       =    0.9787
-------------+----------------------------------   Adj R-squared   =    0.9681
       Total |   .44493366        18  .024718537   Root MSE        =     .0281

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |    .601721   .3077515     1.96   0.074     -.068812    1.272254
         L2. |  -.0581867   .3105654    -0.19   0.855    -.7348506    .6184773
         L3. |    .270739   .2578604     1.05   0.314    -.2910906    .8325686
             |
        lnRT |
         L1. |  -.1243839   .1064412    -1.17   0.265    -.3562994    .1075315
         L2. |   .2068257   .1449287     1.43   0.179    -.1089469    .5225983
         L3. |  -.0442391   .1162335    -0.38   0.710      -.29749    .2090119
             |
       _cons |   1.244187   .7395642     1.68   0.118     -.367185    2.855559
------------------------------------------------------------------------------
```

A.6.3.2.2 Granger causality test

```
. reg lny L.lny L2.lny L.lnRT L2.lnRT in 27/52

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(4, 15)      =  191.33
       Model |  .530550047     4  .132637512           Prob > F      =  0.0000
    Residual |  .010398434    15  .000693229           R-squared     =  0.9808
-------------+------------------------------           Adj R-squared =  0.9757
       Total |  .540948481    19  .028470973           Root MSE      =  .02633

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |   .6078758   .2318829     2.62   0.019     .1136291    1.102123
         L2. |   .1344811   .2292452     0.59   0.566    -.3541434    .6231055
             |
        lnRT |
         L1. |  -.1003009   .0883723    -1.13   0.274    -.2886621    .0880602
         L2. |   .1755116   .0881859     1.99   0.065    -.0124522    .3634754
             |
       _cons |   1.277036    .527348     2.42   0.029     .1530201    2.401051
------------------------------------------------------------------------------

. test L.lnRT

 ( 1)  L.lnRT = 0

       F(  1,    15) =    1.29
            Prob > F =    0.2742

. test L2.lnRT

 ( 1)  L2.lnRT = 0

       F(  1,    15) =    3.96
            Prob > F =    0.0651
```

```
. reg lnRT L.lnRT L2.lnRT L.lny L2.lny in 27/52

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(4, 15)        =    154.66
       Model |  3.56827211         4  .892068028   Prob > F        =    0.0000
    Residual |  .086519073        15  .005767938   R-squared       =    0.9763
-------------+----------------------------------   Adj R-squared   =    0.9700
       Total |  3.65479118        19  .192357431   Root MSE        =    .07595

------------------------------------------------------------------------------
        lnRT |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRT |
         L1. |   .8678222   .2549107     3.40   0.004     .3244928    1.411152
         L2. |  -.2241231   .2543731    -0.88   0.392    -.7663065    .3180602
             |
         lny |
         L1. |    .033513   .6688685     0.05   0.961    -1.392146    1.459172
         L2. |   .7690915   .6612598     1.16   0.263    -.6403505    2.178533
             |
       _cons |  -1.445296    1.52114    -0.95   0.357     -4.68753    1.796938
------------------------------------------------------------------------------

. test L.lny

 ( 1)  L.lny = 0

       F(  1,    15) =    0.00
            Prob > F =    0.9607

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    15) =    1.35
            Prob > F =    0.2630
```

```
. reg lny L.lny L2.lny L.lnRT L2.lnRT in 79/104

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(4, 15)        =     58.24
       Model |     .240344         4     .060086   Prob > F        =    0.0000
    Residual |  .015474447        15   .00103163   R-squared       =    0.9395
-------------+----------------------------------   Adj R-squared   =    0.9234
       Total |  .255818446        19  .013464129   Root MSE        =    .03212

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |   .8884372    .270186     3.29   0.005     .3125494    1.464325
         L2. |   .0469336   .2656654     0.18   0.862    -.5193188    .6131859
             |
        lnRT |
         L1. |  -.0699083   .1150664    -0.61   0.553    -.3151666      .17535
         L2. |   .0694257   .1179144     0.59   0.565    -.1819027    .3207542
             |
       _cons |   .7057562   1.483402     0.48   0.641    -2.456041    3.867553
------------------------------------------------------------------------------

. test L.lnRT

 ( 1)  L.lnRT = 0

       F(  1,    15) =    0.37
            Prob > F =    0.5526

. test L2.lnRT

 ( 1)  L2.lnRT = 0

       F(  1,    15) =    0.35
            Prob > F =    0.5648
```

```
. reg lnRT L.lnRT L2.lnRT L.lny L2.lny in 79/104

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(4, 15)        =      8.12
       Model |  .220138171         4  .055034543   Prob > F        =    0.0011
    Residual |  .101618838        15  .006774589   R-squared       =    0.6842
-------------+----------------------------------   Adj R-squared   =    0.6000
       Total |  .321757009        19  .016934579   Root MSE        =    .08231

------------------------------------------------------------------------------
        lnRT |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRT |
         L1. |   .2255787   .2948684     0.77   0.456    -.4029183    .8540758
         L2. |  -.2423808   .3021664    -0.80   0.435    -.8864333    .4016717
             |
         lny |
         L1. |   .3572152   .6923766     0.52   0.613     -1.11855    1.832981
         L2. |   .5255005   .6807921     0.77   0.452    -.9255735    1.976575
             |
       _cons |   9.741601   3.801355     2.56   0.022     1.639204      17.844
------------------------------------------------------------------------------

. test L.lny

 ( 1)  L.lny = 0

       F(  1,    15) =    0.27
            Prob > F =    0.6134

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    15) =    0.60
            Prob > F =    0.4522
```

```
. reg lny L.lny L2.lny L.lnRT L2.lnRT in 157/182

      Source |       SS           df       MS      Number of obs   =        16
-------------+----------------------------------   F(4, 11)        =     47.13
       Model |  .093634086         4  .023408521   Prob > F        =    0.0000
    Residual |  .005463179        11  .000496653   R-squared       =    0.9449
-------------+----------------------------------   Adj R-squared   =    0.9248
       Total |  .099097265        15  .006606484   Root MSE        =    .02229

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |   .5168884   .2921027     1.77   0.104    -.1260253    1.159802
         L2. |   .2635904   .1816358     1.45   0.175    -.1361873    .6633681
             |
        lnRT |
         L1. |   .2409112   .1852542     1.30   0.220    -.1668305     .648653
         L2. |  -.1352522   .1696247    -0.80   0.442    -.5085936    .2380893
             |
       _cons |   .5196177   1.302332     0.40   0.698    -2.346795     3.38603
------------------------------------------------------------------------------

. test L.lnRT

 ( 1)  L.lnRT = 0

       F(  1,    11) =    1.69
            Prob > F =    0.2200

. test L2.lnRT

 ( 1)  L2.lnRT = 0

       F(  1,    11) =    0.64
            Prob > F =    0.4421
```

```
. reg lnRT L.lnRT L2.lnRT L.lny L2.lny in 157/182

      Source |       SS           df       MS      Number of obs   =        16
-------------+----------------------------------   F(4, 11)        =     21.56
       Model |  .140673468         4  .035168367   Prob > F        =    0.0000
    Residual |  .017938982        11  .001630817   R-squared       =    0.8869
-------------+----------------------------------   Adj R-squared   =    0.8458
       Total |  .158612451        15  .010574163   Root MSE        =    .04038

------------------------------------------------------------------------------
        lnRT |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRT |
         L1. |   .9055016   .3356945     2.70   0.021      .166643     1.64436
         L2. |  -.2395998   .3073727    -0.78   0.452    -.9161225    .4369229
             |
         lny |
         L1. |  -.0313164    .529312    -0.06   0.954    -1.196324    1.133692
         L2. |   .3409077   .3291377     1.04   0.323    -.3835195    1.065335
             |
       _cons |   2.816979   2.359923     1.19   0.258    -2.377176    8.011134
------------------------------------------------------------------------------

. test L.lny

 ( 1)  L.lny = 0

       F(  1,    11) =    0.00
            Prob > F =    0.9539

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    11) =    1.07
            Prob > F =    0.3225
```

```
. reg lny L.lny L2.lny L.lnRT L2.lnRT in 313/338

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(4, 15)        =    200.15
       Model |  1.01519538         4  .253798844   Prob > F        =    0.0000
    Residual |  .019021095        15  .001268073   R-squared       =    0.9816
-------------+----------------------------------   Adj R-squared   =    0.9767
       Total |  1.03421647        19  .054432446   Root MSE        =    .03561

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lny |
         L1. |   .6940376   .3042064     2.28   0.038     .0456371    1.342438
         L2. |   .2741725   .2911556     0.94   0.361     -.346411     .894756
             |
        lnRT |
         L1. |   .0078659   .1664116     0.05   0.963     -.346832    .3625638
         L2. |  -.0475975   .1815685    -0.26   0.797    -.4346017    .3394067
             |
       _cons |   1.142691    1.55048     0.74   0.472    -2.162079     4.44746
------------------------------------------------------------------------------

. test L.lnRT

 ( 1)  L.lnRT = 0

       F(  1,    15) =    0.00
            Prob > F =    0.9629

. test L2.lnRT

 ( 1)  L2.lnRT = 0

       F(  1,    15) =    0.07
            Prob > F =    0.7968
```

```
. reg lnRT L.lnRT L2.lnRT L.lny L2.lny in 313/338

      Source |       SS           df       MS      Number of obs   =        20
-------------+----------------------------------   F(4, 15)        =     91.28
       Model |  1.28353977         4  .320884942   Prob > F        =    0.0000
    Residual |  .052731029        15  .003515402   R-squared       =    0.9605
-------------+----------------------------------   Adj R-squared   =    0.9500
       Total |   1.3362708        19  .070330042   Root MSE        =    .05929

------------------------------------------------------------------------------
        lnRT |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRT |
         L1. |   .6842539    .277076     2.47   0.026     .0936803    1.274827
         L2. |  -.2439087   .3023124    -0.81   0.432    -.8882723    .4004549
             |
         lny |
         L1. |  -.2761272   .5065049    -0.55   0.594    -1.355717    .8034625
         L2. |   .8265493   .4847754     1.71   0.109    -.2067249    1.859823
             |
       _cons |   4.839431   2.581556     1.87   0.080    -.6630242    10.34189
------------------------------------------------------------------------------

. test L.lny

 ( 1)  L.lny = 0

       F(  1,    15) =    0.30
            Prob > F =    0.5937

. test L2.lny

 ( 1)  L2.lny = 0

       F(  1,    15) =    2.91
            Prob > F =    0.1088
```

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