Doctoral Thesis
博士論文

Methodology Study on Relationship between Macro Economy and Container Throughput
(マクロ経済とコンテナ取扱量に関する方法論)

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Content

		Page
	Abstract	3
Part 1	Introduction	5
1.1	Container and Container Transport	5
1.1.1	Container	5
1.1.2	Container Transport	6
1.2	Container Terminal and Throughput	7
1.2.1	Container Terminal	7
1.2.2	Transshipment	8
1.2.3	Container Throughput	8
1.3	Objective	9
1.4	Structure	10
Part 2	Literature Review	12
2.1	Literature on Trade Theories	12
2.2	Literature on GDP, Deflator and Input-Output Analysis	12
2.2.1	GDP Approaches	12
2.2.2	Nominal GDP, Real GDP and Deflator	13
2.2.3	Input-output Analysis	16
2.3	Literature on Container Throughput	18
2.3.1	Container Throughput Generation Mechanism	20
2.3.2	Container Throughput and Containerization	20
2.4	Literature on Econometrics	20
2.4.1	Econometrics Methodology	20
2.4.2	Regression Analysis	21
2.5	Literature on Container Throughput Analysis	22
2.5.1	Relationship between Macro indicators and Container Transport	22
2.5.2	Macro Indicators and Container Throughput	22
2.5.3	Transshipment	24
2.5.4	RWI/ISL Container Throughput Index	25
2.6	Brief Conclusion	27
2.6.1	Relation between Container Throughput and National Account	27
2.6.2	Relation between Container Throughput and GDP	29
Part 3	Methodology Discussion	30
3.1	Review of Past Methodologies	30
3.2	Approach New Methodology	31
3.2.1	Approach Container Throughput Generation Mechanism	31
3.2.2	Approach Consistent Variables	32
3.2.3	Approach Data Processing	32
3.3	Aggregate Analysis Methodology	33
3.3.1	Development of Business Model	33
3.3.2	Transshipment Identification	34
3.3.3	Structure Evaluation	35
3.3.4	Integrated Analysis	36
3.4	Structural Analysis Methodology	36
3.4.1	Development of Business Model	36
3.4.2	Conversion Coefficient	37
3.4.3	Structure Evaluation	37
3.5	Brief Conclusion	38
Part 4	Empirical Aggregate Analysis	40
4.1	Data Source and Process	40
4.2	Structure Evaluation	41
4.2.1	Domestic Industry Structure	41
4.2.2	International Merchandise Trade Structure	42

4.2.3	Transport Structure	43
4.3	Correlation Analysis	46
4.3.1	Correlation between GDP and Container Throughput	47
4.3.2	Correlation between Domestic Demand and Domestic Container Throughput	47
4.3.3	Correlation between Current Account and International Container Throughput	47
4.3.4	Correlation between International Merchandise Trade and International Container throughput	47
4.3.5	Correlation between Gross Demand and Gateway Container Throughput	48
4.3.6	Correlation Coefficient with Nominal and Real Macro Data	48
4.4	Linear Regression	48
4.5	China-plus-Hong Kong Case	50
4.6	Brief Conclusion	50
Part 5	Empirical Structure Analysis	54
5.1	Data Source	54
5.2	Gross Output	54
5.3	Container Cargo Weight and Value	56
5.4	Unit Weight of Container Cargo	57
5.5	Conversion Coefficient	57
5.6	Input-output Analysis on Container Throughput	61
Part 6	Conclusion	66
6.1	Methodology Summary	66
6.1.1	Common Points	66
6.1.2	Aggregate Analysis	66
6.1.3	Structural Analysis	67
6.2	Study Review	68
6.2.1	Comparison with Frontier Studies	68
6.2.2	Contribution	68
6.3	Research Prospect	69
Appendix 1	Macroeconomic Indicators of Japan	72
Appendix 2	Macroeconomic Indicators of China	73
Appendix 3	Macroeconomic Indicators of Korea	74
Appendix 4	Macroeconomic Indicators of Hong Kong SAR	75
Appendix 5	Primary and Secondary Industry Value Added	76
Appendix 6	Container Throughput	77
Appendix 7	Japanese Input-Output Table with 13 industries （Leontief Inverse Matrix）	79
Appendix 8	Harmonization System Code (HS-Code)	80
Appendix 9	Macroeconomic Statistics in Industry Wise	85
	Notes	89
	Reference	91

Abstract

Container transport has been so closely connected with macro economy since its birthday in 1956, and now more than half international seaborne trade in terms of value are carried by containers from frozen tuna to aircraft parts.

As port infrastructure are generally considered to be a long-term investment offering steady returns and container transport has exhibited quite potential due to its unique contribution to globalization, container terminal financing and investment has become one of the choices for government, asset managers, corporate investors and even public pension funds. Definitely, supply demand analysis in such kind of capital-intensive industry will be dealt seriously for every specific case.

Container throughput is taken as demand factor in supply demand analysis since container terminals charge carriers by container movement between terminal and vessel, namely container throughput. Therefore, container throughput research is always a hot topic in container transport field.

Due to its close connection with national or regional economic development, container throughput was always analyzed by macro indicators in regression approach, especially GDP data was always adopted integrally to make regression analysis with container throughput. However, most researches focused on statistical model comparison or optimization but rarely discussed economic facts behind container throughput and macro indicators.

Meanwhile, system structure evaluation was hardly found in most past researches while term of data series and data processing were seldom mentioned. However, a stable system structure was a sufficient condition for sound regression. Furthermore, this study did not find any structural analysis on relationship between container throughput and various industries in macroeconomic structure which could tell us more information of container throughput generation mechanism.

After literature reviewing, System of National Account (SNA) was recognized as a treasure for macroeconomic analysis when GDP data was just one of macroeconomic indicators. SNA did not only provide statistics data source but also many efficient methodologies for macroeconomic analysis, just like GDP expenditure approach or input-output analysis.

By use of SNA's methodologies, this study firstly raised question on GDP as a suitable variable to explain container throughput after examining economic facts behind GDP and container throughput and re-organized aggregate regression analysis methodology while proposing structural analysis methodology for national container throughput analysis before we tried to integrate aggregate and structural analysis together.

Firstly, this study confirmed causal but independent relationship between container throughput and macro indicators in national account.

Secondly, this study distinguished business model from statistical model and made first attempt to create business model against container throughput generation mechanism which divided gross container throughput into domestic, international and international transshipment segments by trade nature.

Thirdly, gateway container throughput not gross container throughput was identified to be more easily correlated with macro economy while international transshipment throughput did not make remarkable contribution to hub's economy.

Finally, data series' term and processing were strongly emphasized. Macro indicator data series in real term and input-output table by producer's price were selected to match the economic facts behind container throughput as much as possible in this study.

Besides above common points, specific methodologies for both aggregate and structural analysis were developed individually. For aggregate analysis, macro indicators including value of domestic demand and international merchandise trade from GDP expenditure approach were selected as independent variables to correspond to domestic and international container throughput segments by most reasonable causality. Secondly, the evaluations of industry structure, trade structure and transport structure were proposed to qualitatively describe the economic background when aggregate regression analysis was made. Thirdly, both quantitative and qualitative analysis was integrated to explore exact causality and avoid nonsense regression in container throughput analysis.

For structural analysis, input-output table was chosen to make analysis on the mechanism between industries and container throughput. Leontief inverse matrix was used to establish function between container throughput segments and industries' final demand after conversion coefficients were calculated by trade statistics.

In line with above methodologies, the empirical analysis was made by macro indicators and container throughput data from Japan, China, Korea and Hong Kong SAR.

Both aggregate and structural empirical analyses made use of same generation mechanism and data source from SNA evidently supported with each other and methodologies we proposed as well.

This study started with container throughput generation mechanism and the outcome further demonstrated the contents of this mechanism. The new demonstration included two parts. Firstly, container throughput was evidently connected with macro economy. Though GDP was questioned to be a suitable variable for regression analysis, domestic demand, international merchandise trade and other indicators in SNA were still able to explain container throughput. Secondly, different macroeconomic structure had different driving force on container throughput. Industry structure was a decisive factor while transport structure mutually reinforced with container throughput as well as container terminal investment.

Meanwhile, structural analysis was additional quantitative study for industry structure evaluation in aggregate analysis. Aggregate analysis illustrated container throughput trend while structural analysis identified every industry’s contribution to gateway container throughput. The key industries identified by structural analysis in this study was logic and in line with common sense. Structural analysis was consistent with aggregate analysis while both approaches identified physical industries generated container throughput efficiently.

Part 1 is the background and objective of this study after reviewing features of container, container transport and container throughput as well as their influence on container terminal investment.

Part 2 is literature review and brief conclusion of past researches. Though container transport is just a small topic in economic research, a lot of well-known scholars confirmed its unique contribution to global economic development and many research have been made on container throughput. However, GDP was questioned as a suitable independent variable to explain container throughput in this chapter after independence between container throughput and macro indicators was confirmed.

Part 3 is the discussion on aggregate and structural analysis methodology. This study approached container throughput generation mechanism and integrated quantitative and qualitative analysis together. It clearly exhibited the difference between past GDP-based and new methodologies for regression analysis and proposed input-output analysis tool to make structural analysis on container throughput.

Part 4 is empirical aggregate analysis which was made by the data in last two decades from Japan, China, Korea and Hong Kong while China-plus-Hong Kong was verified simultaneously. Integrated analysis was implemented after data process and key macroeconomic structures evaluation were made.

Part 5 is empirical structural analysis to verify endogenous dynamics from industries development to container throughput. By use of Japanese Input-Output Table and trade statistics, this study tried to set up matrix function between final demand and container throughput even for non-physical industries.

Part 6 is the conclusion of research which summarized methodologies discussed in this study and made comparison with other frontier researches. This part indicated that SNA was treasure house with so many valuable data as well as methodologies and should be further developed.

Anyway, the aim of this study was to develop new methodologies by matching economic facts behind macro indicators and container throughput as much as possible. Since this study focused on methodology, it was independent to statistical models so that there is not any challenge on statistical model or algorithm in this study and only correlation analysis and simplest linear regression analysis was made. This study made every effort to explain methodology with concise economic facts and the simplest language while trying to provide more statistics materials rather than use complicated mathematic tools.

Keyword: macro economy, gateway container throughput, aggregate analysis, structural analysis, methodology

Part 1 Introduction

"……Decades later, when enormous trailer trucks rule the highways and trains hauling nothing but stacks of boxes rumble through the night, it is hard to fathom just how much the container has changed the world……"

---Marc Levinson, The Box

Marc Levinson (2006), the winner of the 2007 Anderson Medal from Society for Nautical Research, depicted exciting maiden voyage of container transport in the beginning of "The Box" as below:

"On April 26th, 1956, a crane lifted fifty-eight aluminum truck bodies aboard an aging tanker ship moored in Newark, New Jersey. Five days later, the Ideal-X sailed into Houston, where fifty-eight trucks waited to take on the metal boxes and haul them to their destinations. Such was the beginning of a revolution".

The maritime container transport made shipping cheap, and by doing so changed the shape of the world economy over the years (World Trade Report 2013). Especially within last thirty years we have witnessed the rapid development of container transportation including large-size trend of container vessel, soar of container trade volume as well as escalation of container port throughput. The world container port throughput historically recorded 699 million TEU in 2016 (Review of Maritime Transport (2017)) with more than 19 times of 36 million TEU in 1980.

Container transport development drives gradual transportation cost saving and provides strong technical support to global trade. Bernhofen et al. (2013) concluded that containerization had a stronger impact on driving globalization than trade liberalization, especially for developed countries and North–North trade. His study found the concurrent effect of containerization was to raise bilateral trade flows on average by 320% within first five years in twenty-two industrialized countries and cumulative average treatment effect of containerization over a twenty-year time period amount to a staggering 790% which could be compared with the contribution of GATT to international trade.

1.1 Container and Container Transport

1.1.1 Container

Maritime container is a standard steel box used for general cargo's transport. In Japanese Annual Report of Port Statistics released by Ministry of Land, Infrastructure, Transport and Tourism (MLIT), maritime container was defined as container used to stuff cargo when it is loaded to or discharged from vessel(1).

As per ISO's standard, there are several kinds of maritime containers. However, two main kinds of maritime containers, twenty feet and forty feet container, occupy about ninety five percent of all container fleet. Figure 1.1 illustrates general container's image with twenty feet and forty feet container's specifications.

Type	Internal Dimension (mm)	Door Opening (mm)	Cubic Capacity (m^3)	External Dimension (mm)	Tare Weight (kg)	Maximum Gross Weight (kg)	Maximum Payload (kg)
20'GP	L: 5,898 W: 2,352 H: 2,392	W: 2,340 H: 2,280	33.2	L: 6,058 W: 2,438 H: 2,591	2,068-2,366	30,480	28,412-28,114
40'GP	L: 12,032 W: 2,352 H: 2,392	W: 2,340 H: 2,280	67.7	L: 12,192 W: 2,438 H: 2,591	3,557-3,876	30,480	26,923-26,604
40'HC	L: 12032 W: 2,352 H: 2,697	W: 2,340 H: 2,585	76.3	L: 12,192 W: 2,438 H: 2,896	3,734-4,060	30,480	26,764-26,420

Figure 1.1 ISO Container Specifications (Adopted from homepage of Kambara Kisen Shipping Company Limited http://www.kambara-kisen.co.jp/liner/container/)

The containers will be loaded onto cellular container vessel (See Figure 1.2) in port of loading after cargo is stuffed into containers by shippers. These containers will be discharged to terminal when the same vessel arrives in port of discharging. Consignee will pick up containers and un-stuff the cargo from containers.

Figure 1.2 Cellular Container Vessel (Adopted from homepage of Ocean Network Express)

Maritime container is designed to carry various kinds of commodities. Just like the biggest container shipping company Maersk Line's homepage shows, containers apply to most merchant cargoes including agriculture, apparel and footwear, automotive, chemicals, dangerous cargo, electronics, fish and seafood, fruit and vegetables, machinery, oversized cargo, protein, pharmaceuticals commodities and so on (See Figure 1.3). Indeed, container has been widely used and maritime container transport carries more than half seaborne trade in value term.

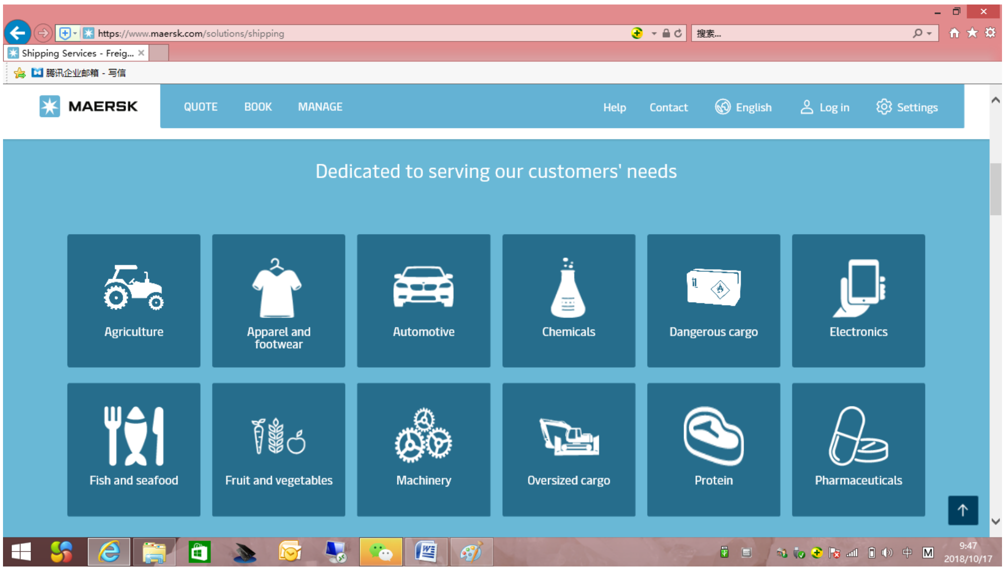


Figure 1.3 Main Kinds of Containerizable Commodity Illustrated by Maersk Line

1.1.2 Container Transport

Maritime container transport is to unitize general cargo using containers. Standardizing the cargo unit allowed liner companies to invest in mechanized systems and equipment which would automate the transport process and raise productivity. The container transport system had three components. Firstly, the product transported, general cargo, was packed in standard units that could be handled across the whole transport operation. Secondly, investment was applied at each stage to produce an integrated transport system with vehicles at each stage in the transport chain built to handle the standardized units. Finally, the third step was to invest in high-speed cargo-handling facilities to transfer the container between one part of the transport system and another. Container terminals, inland distribution depots and container stuffing facilities where part loads could be packed into containers all played a part in this process(2).

Figure 1.4 shows us the historical evolution of world GDP, merchandise trade and seaborne shipment and container throughput. It has been observed that over the years, world seaborne trade has grown about 150 percent as fast as the world GDP due to the multiplier effect resulting from, among others, the globalization of production processes, increased trade in intermediate goods and components, and the deepening and extension of global supply chains.

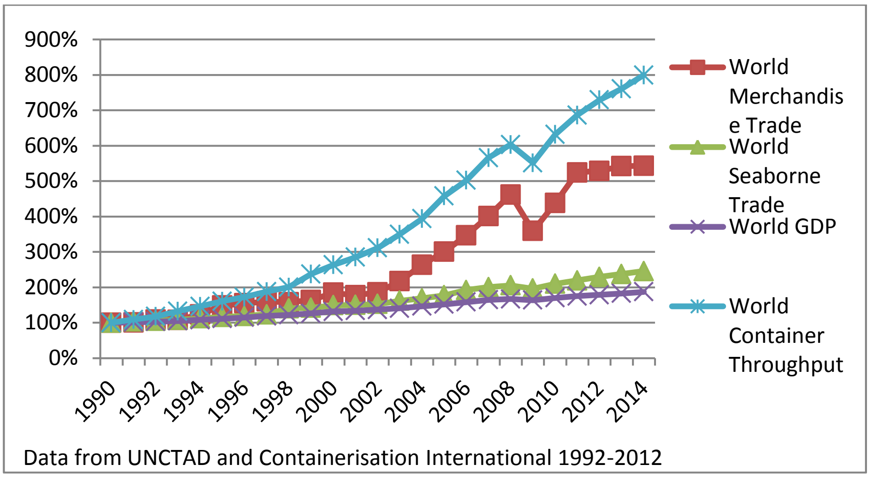


Figure 1.4 World GDP, Merchandise Trade, Seaborne Trade and Container Throughput (1990-2014) (1990=100)

According to Review of Maritime Transport (2013) released by UNCTAD, for many decades, containerized trade has been the fastest-growing market segment accounting for over 16 percent of global seaborne trade by volume in 2012 and more than half by value (in 2007)[(3)].

Compared with bulk and other maritime transportation mode, global container trade has more service frequency and wider geographic coverage. From milk to mobile phone and even to aircraft parts, containerization has been connecting with everybody's daily life and global economy too closely to be ignored in any respect. Martin Stopford (2009) pointed out that a good starting point for container transport analysis was the relationship between container cargo and world economic activity[(4)].

From the beginning of the 21st century, twice global economic crises have brought serious impact to container transport industry and pushed carriers to pursue cost-saving as well as economic scale together which have brought unprecedented development to this industry.

Nowadays, global container transport exhibits its unique features including container vessel upsizing, market concentration, liner shipping alliance and green shipping while achieving high speed development. Table 1.1 shows current expansion of world container fleet and its capacity. Nevertheless, the market witnessed the arrival of the largest container ship ordered by CMA-CGM with capacity 22,000 TEU in 2017.

Table 1.1 Containership Fleet and Capacity

Containership Fleet	Numbers				Capacity (thousand TEU)			
	2013	2014	2015	2016	2013	2014	2015	2016
100-999 TEU	1,172	1,135	1,090	1,070	711	691	663	649
1,000-2999TEU	1,932	1,885	1,866	1,883	3,482	3,399	3,354	3,375
3,000+TEU (Panamax)	951	901	866	844	3,949	3,778	3,639	3,549
4-7,999 TEU (Post-Pmax)	577	628	658	680	3,411	3,664	3,814	3,917
8-11,999 TEU (Post-Pmax)	352	401	459	533	3,123	3,555	4,096	4,788
12,000+ TEU (Post-Pmax)	117	151	193	239	1,577	2,058	2,695	3,457
Total	5,101	5,101	5,132	5,249	16,254	17,145	18,260	19,735
Growth Rate	0.1%	0.0%	0.6%	2.3%	5.9%	5.5%	6.5%	8.1%

Data source: from Container Intelligence Monthly, Clarkson Research, Vol.18, No.1, January, 2016

1.2 Container Terminal and Throughput

1.2.1 Container Terminal

Container terminal is a essential infrastructure for maritime container transport which links container vessel and inland distribution system. With the container vessel's upsizing and strict control of carbon emission, it does not only require enough container terminals but also require more modern container terminals (Tetsuya Koizumi (2011)) with deeper draft, huge container gantry and "green" facilities which further upgrade the demand of more financing and investment than before.

Recent case is Chinese central government approved Shanghai Yangshan Container Port Phase 4 Project in October 18th, 2014. The project invested CNY 12.8 billion and developed world biggest automatic container terminal with 6.3 million TEU's capacity per year. This has not included infrastructure cost previously spent for thirty kilometers sea-crossing bridge between Yangshan Island and mainland.

The container terminal's investment is quite big. However, statistics showed global container terminals' utilization level was not optimistic as expected (See Table 1.2).

Table 1.2 Container Terminal Utilization

Utilization Level	North America	Europe	Asia	Middle East /South Asia	Latin America	Africa	Oceania
Current (2015)	61.8%	59.6%	73.0%	68.4%	61.2%	60.7%	65.2%
Forecast (2020) based only on confirmed plans	62.4%	58.8%	74.9%	61.7%	55.7%	51.8%	66.9%
Forecast (2020) based on confirmed + unconfirmed plans	56.0%	56.6%	74.2%	59.7%	52.5%	45.7%	65.9%

Data Source: from Drewry Global Container Terminal Operators Annual Review (2016)

Table 1.2 indicated container terminal's investment involves high risk. Thus, much attention was paid to container throughput which is known as demand factor in container terminal investment analysis.

1.2.2 Transshipment

With the containerization of general cargo enabling ships of increasing size with lower unit costs to be loaded and unloaded rapidly in ports equipped for that purpose, containers needed to be transshipped to and from smaller vessels and barges in order to serve shallow ports unable to accommodate the large ships and to collect and distribute small numbers of containers.

Although there are currently about 400 ports which have a significant container throughput, the top 60 handle 98% of the throughput. Many countries now have only one or two major container ports serving the deep-sea trades, supported by transshipment via a range of smaller ports handling short-sea and distribution trade (Alfred J. Baird (2002)).

Nowadays, container transshipment has become another trend of the logistics of intercontinental liner services and has created a new and rapidly growing maritime industry with economic spinoffs including job creation. Many port authorities, for example, Pusan and Jebel Ali, have invested large sums in infrastructure and marketing in order to attract transshipments.

1.2.3 Container Throughput

Before container transport system was invented, port authority only made statistics on port traffic volume, namely seaborne trade volume in ton base. Port traffic volume is a purely physical statistics which ignores the attribute of commodities' value.

With rapid escalating of container traffic, port authorities recently began to make additional container throughput statistics to indicate port container traffic scale and capacity. Container throughput is usually measured by container movements between vessel and terminal in term of TEU. Same as port traffic volume, container throughput is only a purely physical statistics which ignores the attribute of commodities' value.

Whatever domestic or international trade, one twenty feet container discharged from vessel to the terminal will bring one TEU throughput same as one twenty feet container loaded from the terminal to vessel. Figure 1.5 illustrates the simplest container transport scenario and container throughput calculation model.

In the transshipment case, one twenty feet container will be discharged from first vessel to the terminal and loaded from terminal to second vessel consecutively, there are two container movements and container throughput will be counted as two TEUs accordingly.

All the countries and international organizations adopt above definition to make statistics. For example, Japan's MLIT makes such kind of statistics and defines container throughput as number of empty containers and containers used for cargo transport and all these containers will be converted into twenty-equivalent-unit (TEU) basis against its length (See Table 1.3)[(5)]. Japanese Annual Report of

Port Statistics (2011) announced international container throughput is 17,503,465 TEU while domestic container throughput is 3,632,239 TEU.

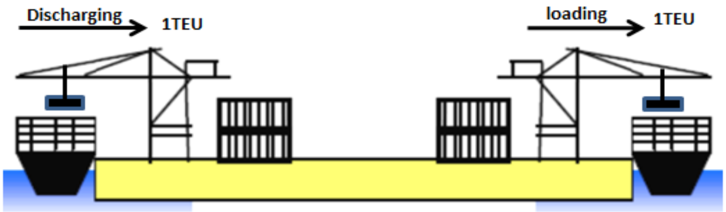


Figure 1.5 Container Throughput Calculation Model

Table 1.3 Container Throughput Conversion Table

Length of Container	Container Type	TEU
Less than 9 feet	8 feet	0.4
9 -11 feet excluding 11 feet	10 feet	0.5
11-20 feet excluding 20 feet	12 feet	0.6
20-24 feet excluding 24 feet	20 feet	1.0
24-35 feet excluding 35 feet	24 feet	1.2
35-40 feet excluding 40 feet	35 feet	1.75
40-45 feet excluding 45 feet	40 feet	2.0
45 feet and above	45 feet	2.25

Data source: from Japanese Annual Report of Port Statistics (2011).

By Japanese Annual Report of Port Statistics (2011)(5), we can see national container throughput is just the sum of maritime container amount through port. The only one data process for aggregate container throughput is to convert forty feet container and other kind of containers into TEU basis according to container length. This conversion is just a physical concept without any connection with value term.

Basically, container terminal charges shipping companies by the container movements so that container throughput has become demand factor in supply demand analysis of container terminal investment.

Container throughput is also used to indicate the short−term international trade trend recently. A joint research has been made by two famous institutes of trade and shipping researches, RWI(6) and ISL(7) and indicates high correlation between international trade data in value term and international container throughput(8).

1.3 Objective

Transport is to resolve uneven geographical resource distribution and trade, whatever domestic or international trade, triggers transport demand. Thus, the study on the relationship between international merchandise trade in value term and seaborne trade volume or port traffic volume in ton base is always a hot topic in macroeconomic field. For example, Professor Martin Stopford made use of linear regression analysis between world GDP and world seaborne trade and he surprised to find relevant correlation coefficient was 0.99(9).

For container transport system, container terminal is an indispensable infrastructure for regional and international trade development which connects with transport costs reducing, greater market access and connectivity and industrial development (Olaf Mark et al. (2012); Salvador et al. (2013)), container throughput, as demand factor and evaluation standard, has also received much attention from both private and public sectors.

A lot of papers on container throughput analysis were found both for academic research and practical purpose (Chen Taotao et al. (2008); Business Monitor International (2013)). Main research focused on national or regional container throughput aggregate analysis by use of two prevailing methodologies, namely time series analysis and regression analysis. Most previous studies made use of these two approaches individually or sometimes combined together to analyze container throughput while focusing on econometric model selection and its analytical precision (Yang Bo (2006); Zhao Yapeng et al. (2006); Yang Jinhua et al. (2014); Liu Zhijie et al. (2007); Le Meilong et al. (2013)).

GDP was a most often used variable in past regression analysis. For example, Masayoshi Kubo et al. (2000) found correlation coefficient between Indonesia’s container throughput and GDP was 0.9944 when the sum of China mainland and Hong Kong’s container throughput has high correlation coefficient 0.9986 with China mainland's GDP.

But even though GDP is one of the most important indicators of macro economy and container throughput is believed to closely connect with macro economy, does it mean GDP is or can be a suitable variable to explain container throughput in the open macro economy (See Figure 1.6)

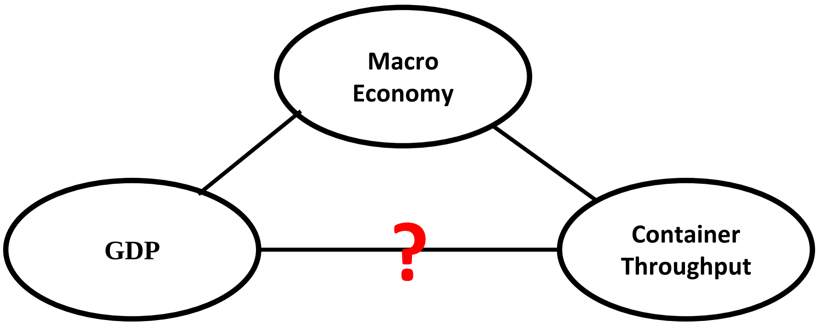


Figure 1.6 Relationships among Macro Economy, GDP and Container Throughput

There are two extreme cases which cannot explain the relationship between GDP and container throughput. The first is United States and China. Though GDP of United States is higher than the same of China, the latter's container throughput is bigger than United States'. The second is Korea and Japan. Korea's container throughput was almost same as Japan's while Japan's GDP is much higher than Korea's

This study argued GDP was not a suitable independent variable to explain gross container throughput. Though in some specific case, GDP was correlated with container throughput, it did not imply causation.

Meanwhile, this study did not find any paper for structural analysis between macro economy and container throughput. For example, China and Japan has a very big difference in national gross container throughput. Besides macroeconomic scale, what kind of macroeconomic structure leads to such kind of big difference or which industries most stimulate container throughput? Such kind of question should be very interesting. However, so far the research on the relationship between container throughput and industry structure was hardly found.

This study never tried to challenge any new statistical model or algorithm since so many well-developed econometric tools were available while focusing on methodologies to make container throughput aggregate and structural analysis against basic economic facts.

For aggregate analysis, the core of this study was to re-organize methodology including business model developed by container throughput generation mechanism while removing international transshipment throughput before regression analysis was made. After that, stable system structure evaluation was made to ensure a sound regression analysis before integrated analysis was carried. It was also recommended to process macro indicator data series by deflator to match the economic facts behind variables as much as possible.

For structural analysis, input-output table was proposed to establish the relationship between container throughput and various industries in macroeconomic system. Especially, this study revealed the relationship between container throughput and non-physical industries which could explain container throughput amount in developed countries which had not large-scale manufacturing industry.

This study emphasized that SNA was a big treasure which did not only provide statistical data source but also a lot of efficient methodologies, just like GDP expenditure approach and input-output analysis. GDP was only one indicator in SNA and more exploration of SNA would be interesting and meaningful for container throughput research. Empirical analysis was made both for aggregate and structural analysis accordingly.

Since this study focused on relationship between macro economy and container throughput, only regression analysis for aggregate analysis was discussed in this study and there is not time-series analysis made here.

1.4 Structure

This paper includes six parts.

Part 1 is the background and objective of this research after reviewing features of container, container transport and container throughput as well as their influence on container terminal investment.

Part 2 is literature review and brief conclusion of past researches. Though container transport is just a small topic in economic research, a lot of well-known scholars confirmed its unique contribution to global economic development and many researches have been made on container throughput. However, GDP was questioned as a suitable independent variable to explain container throughput in this chapter after independence between container throughput and macro indicators was confirmed.

Part 3 is the discussion on aggregate and structural analysis methodology. This study approached container throughput generation mechanism and integrated quantitative and qualitative analysis together. It clearly exhibited the difference between past GDP-based and new methodologies for regression analysis and proposed input-output analysis tool to make structural analysis on container throughput.

Part 4 is empirical aggregate analysis which was made by the data in last two decades from Japan, China, Korea and Hong Kong while China-plus-Hong Kong was verified simultaneously. Integrated analysis was implemented after data process and key macroeconomic structures evaluation were made.

Part 5 is empirical structural analysis to verify endogenous dynamics from industries development to container throughput. By use of Japanese Input-Output Table and trade statistics, this study tried to set up matrix function between final demand and container throughput even for non-physical industries.

Part 6 is the conclusion of research which summarized methodologies discussed in this study and made comparison with other frontier researches. This part indicated SNA was a treasure house with so many valuable data as well as methodologies and should be developed more broadly and deeply. Though GDP is still the core of SNA, it is just one index of the whole system. The full usage of SNA will enrich our methodology to make more contribution to regional and national container throughput analysis.

Part 2 Literature Review

"……When we think about technology that changed the world, we think about glamorous things like the internet. But if you try to figure out what happened to world trade, there is a really strong case to be made that it was the container, which could be hauled off a ship and put onto a truck or a train and moved on….."

---Paul Krugman, 2009

Most previous studies on container throughput were made with macro indicators while GDP was one of the most employed indices due to close relationship between container transport and macro economy. However, container throughput is a complex system which is influenced by many factors. It is necessary to have a literature review of macroeconomic statistics, container throughput generation mechanism and basic econometrics methodology.

2.1 Literature on Trade Theories

In consideration of transport was the production of trade demand, this study firstly reviewed the development of trade theories, and tried to find the implication to trade and transport.

The classical trade theory discussed the contribution of specialization to the development of productive forces in perfect competition status and indicated that inevitable outcome of specialization was the development of trade and thereafter transportation. Adam Smith (1776) set up theoretical milestone with "The Inquiry into the Nature and Causes of the Wealth of the Nations" and strongly advocated freedom of international trade.

In 1930s, John Maynard Keynes (1936) published "The General Theory of Employment, Interest and Money" and pointed out that there was no ideal state of full employment. He inherited Adam Smith's positive evaluation on export trade for national wealth.

At the beginning of 1980s, economists headed by Krugman put forward the new trade theory and emphasized that under imperfect competition, specialization and scale economy is not only the driving force of increasing returns, but also endogenous power for international trade.

At the turn of the century, Masahisa Fujita, Krugman and Venables (2011) published their classic textbook "The Spatial Economy: Cities, Regions and International Trade" which was called the fourth wave of the increasing returns revolution in economics. Spatial economics explores the influencing factors of enterprise location from the micro level and explain the agglomeration of various economic activities from the macro level, especially the important role of transport cost, increasing returns and linkage effect on the spatial agglomeration. Spatial economics further clarified the existence of transport costs and self-reinforcing mechanism of industrial agglomeration based on increasing returns. The notion of increasing returns helps us to easily understand upgrading size of container vessel and container terminal.

2.2 Literature on GDP, Deflator and Input-Output Analysis

Since Keynes published his General Theory in 1936, GDP has become the most important macroeconomic indicator. Though it is always criticized from many aspects, GDP is still a benchmarking indicator of macroeconomic growth. At least, there is no any other comprehensive indicator has been found to replace it so far. Just as Diane Coyle (2014) pointed out "GDP statistics and Keynesian macroeconomic policy were mutually reinforcing. The story of GDP since 1940 is also the story of macroeconomics." It is believed that this is one of the reasons why GDP was always used as an independent variable in container throughput analysis.

2.2.1 GDP Approaches

According to many classic textbooks, GDP can be estimated in three ways:

a. The sum of all final expenditures within the economy (the expenditure approach);

b. The sum of all production activity within the economy (the production approach), as estimated using gross value added;

c. The sum of all income generated by production within the economy (the income approach).

In order to match the economic facts behind data, this study will use both GDP expenditure and production approach and delivered result of expenditure approach only to control the length of this paper. In fact, production approach provided same evidence as expenditure approach to support our methodologies.

---Expenditure Approach

According to Yanagita Tatsuo (2008) indicated in "International Political Economic System", the

GDP in the closed economic system can be acquired with expenditure approach as below formula:

$$\text{GDP} = \text{C} + \text{I} + \text{G} \tag{2.1}$$

GDP: gross domestic product
C: personal consuming
I: private investment
G: government expenditure

In formula (2.1), GDP just stands for domestic demand. There is only domestic transport demand including container transport and not international transport at all in closed economic system. Apparently, domestic container transport meets part of domestic merchandise trade demand.

In the open macroeconomic system, the GDP data can be approached as below formula (2.2):

$$\text{GDP} = \text{C} + \text{I} + \text{G} + \text{X} - \text{I}_\text{m} = \text{C} + \text{I} + \text{G} + \text{CA} \tag{2.2}$$

X: export goods and services in value term
I_m: import goods and services in value term
CA: current account or net export.

Figure 2.1 is an example of GDP expenditure approach released by Japanese government. Compared with closed macro economy, open macro economy generates international trade including both goods and services trade but only international merchandise trade triggers international transport demand directly. Obviously, container transport meets part of transport demand both for domestic demand and international merchandise trade in open macro system when other transport modes just like bulk and tanker transport meet rest transport demand together.

---Production Approach

The production approach, which is also called the output approach, measures GDP as the difference between value of output less the value of goods and services used in producing these outputs during an accounting period. The production approach is defined as below equation (2.3):

$$\text{GDP} = \text{PRI} + \text{SEC} + \text{TER} \tag{2.3}$$

PRI: primary industry value added
SEC: secondary industry value added
TER: tertiary industry value added

Figure 2.2 is an example of GDP production approach released by Japanese government. In Japanese GDP statistics, primary industry includes Agriculture, Forest and Fishery industry while secondary industry includes Mining industry and Manufacturing industry. Obviously, container transport meets part of transport demand of primary industry and secondary industry while having no direct relationship with tertiary industry. It is believed that (PRI+SEC) is a candidate macro indicator which connects with container throughput in regression analysis.

2.2.2 Nominal GDP, Real GDP and Deflator

Nominal GDP is the sum of all goods and services with current price on the market. But with time going by, same goods and services would produce different GDP data when the unit price fluctuates. Therefore, real GDP with constant price are introduced into macroeconomic theory to indicate goods and services volume's fluctuation. GDP deflator is also designed to indicate the price fluctuation volatility. GDP deflator can be derived from below formula (2.4):

$$\text{GDP Deflator} = \text{Nominal GDP}/\text{Real GDP} \tag{2.4}$$

By use of deflator, not only GDP but also other economic data can be changed into real basis. Since the nature of container throughput is cargo's physical weight or measurement but not cargo value, economic data in real basis will comparatively reflect more physical facts and become a better independent variable for container throughput analysis.

Most countries and international organization release nominal GDP, real GDP and deflator annually. Table 2.1 shows us four countries/regions' deflator from 1990 to 2014. Chinese price fluctuated

１．国内総生産（支出側、実質：連鎖方式）		
（単位：１０億円）　（平成17暦年連鎖価格）	実数	
項　目	平成6年度 1994	平成23年度 2011
１．　民間最終消費支出	259,853.9	304,745.4
（１）家計最終消費支出	255,336.4	297,700.8
ａ．国内家計最終消費支出	251,852.2	296,464.8
ｂ．居住者家計の海外での直接購入	4,065.7	1,967.4
ｃ．（控除）非居住者家計の国内での直接購入	221.0	696.8
（再掲）		
家計最終消費支出（除く持ち家の帰属家賃）	219,013.7	248,001.5
持ち家の帰属家賃	36,249.2	49,736.8
（２）対家計民間非営利団体最終消費支出	4,521.1	7,045.9
２．　政府最終消費支出	70,601.5	99,349.9
（再掲）		
家計現実最終消費	298,844.2	362,256.6
政府現実最終消費	31,662.3	41,855.2
３．　総資本形成	120,065.0	97,744.9
（１）総固定資本形成	121,275.6	100,644.9
ａ．民間	84,995.5	80,331.0
（ａ）住宅	25,022.9	12,997.4
（ｂ）企業設備	58,499.9	67,448.8
ｂ．公的	39,088.0	20,249.7
（ａ）住宅	1,374.6	447.7
（ｂ）企業設備	9,988.2	5,389.0
（ｃ）一般政府	27,724.5	14,414.0
（２）在庫品増加	-906.4	-2,613.5
ａ．民間企業	-878.4	-2,673.0
（ａ）製品在庫	-125.2	595.3
（ｂ）仕掛品在庫	-366.5	-1,304.7
（ｃ）原材料在庫	-736.0	-741.2
（ｄ）流通在庫	273.4	-1,186.3
ｂ．公的	-33.9	35.1
（ａ）公的企業	-8.0	7.2
（ｂ）一般政府	-23.3	27.9
４．　財貨・サービスの純輸出	-647.3	11,966.0
（１）財貨・サービスの輸出	40,052.6	82,280.5
ａ．財貨の輸出	34,974.2	73,003.8
ｂ．サービスの輸出（含む非居住者家計の国内での直接購入）	5,166.3	9,293.7
（２）（控除）財貨・サービスの輸入	40,699.9	70,314.5
ａ．財貨の輸入	29,121.1	58,733.6
ｂ．サービスの輸入（含む居住者家計の海外での直接購入）	11,478.5	11,613.2
５．　国内総生産（支出側）	447,167.4	513,742.1
６．　開差(5-(1+2+3(1)a(a)+3(1)a(b)+3(1)b+3(2)a+3(2)b+4))	-4,339.3	-377.2
（参考）交易利得	9,728.6	-18,507.7
国内総所得	456,895.9	495,234.5
海外からの所得の純受取	3,607.9	15,472.7
海外からの所得	15,620.9	21,531.9
（控除）海外に対する所得	12,013.0	6,059.1
国民総所得	460,503.8	510,707.2
（参考）国内需要	451,058.7	501,356.8
民間需要	341,681.2	381,793.4
公的需要	109,394.9	119,511.2
(参考) 国内総生産（支出側）（除くFISIM)	440,217.2	505,533.6
家計最終消費支出（除くFISIM)	249,780.6	292,639.8
財貨・サービスの輸出（除くFISIM)	39,694.3	81,966.2
（控除）財貨・サービスの輸入（除くFISIM)	40,470.8	70,347.4
（注）１．財貨・サービスの純輸出は連鎖方式での計算ができないため、財貨・サービスの輸出－財貨・サービスの輸入により求めている。このため寄与度とは符号が一致しない場合がある。		
２．国内総所得＝国内総生産＋交易利得		
３．国民総所得＝国内総所得＋海外からの所得の純受取		

Figure 2.1 Example of GDP Expenditure Approach Released from Japanese Government

３．経済活動別国内総生産（実質：連鎖方式）		
（単位：１０億円）　（平成17暦年連鎖価格）	実数	
項　目	平成6暦年	平成23暦年
	1994	2011
１．　産業	396,351.1	444,775.9
（１）農林水産業	7,378.3	6,271.3
ａ．農業	6,250.3	5,443.2
ｂ．林業	66.9	152.7
ｃ．水産業	1,103.0	689.4
（２）鉱業	487.8	192.4
（３）製造業	81,251.5	106,799.1
ａ．食料品	12,764.8	12,724.0
ｂ．繊維	1,469.9	520.5
ｃ．パルプ・紙	2,731.4	2,243.6
ｄ．化学	7,760.7	8,574.2
ｅ．石油・石炭製品	9,521.8	5,389.7
ｆ．窯業・土石製品	3,652.2	2,846.5
ｇ．鉄鋼	5,860.4	5,779.3
ｈ．非鉄金属	1,442.7	2,058.0
ｉ．金属製品	5,529.7	4,543.1
ｊ．一般機械	8,966.2	11,373.3
ｋ．電気機械	4,988.6	26,960.5
ｌ．輸送用機械	8,901.2	12,821.6
ｍ．精密機械	1,497.7	1,702.8
ｎ．衣服・身回品	2,715.0	698.6
ｏ．製材・木製品	1,413.9	619.7
ｐ．家具	1,388.4	496.1
ｑ．印刷	3,770.3	3,298.9
ｒ．皮革・皮革製品	383.4	105.2
ｓ．ゴム製品	1,102.5	1,125.2
ｔ．その他の製造業	4,342.0	4,738.5
（４）建設業	42,167.1	25,823.0
（５）電気・ガス・水道業	9,224.9	9,626.8
ａ．電気業	5,109.1	5,176.9
ｂ．ガス・水道・熱供給業	4,278.8	4,320.4
（６）卸売・小売業	65,203.3	65,740.3
ａ．卸売業	40,234.5	37,693.4
ｂ．小売業	24,972.6	28,314.2
（７）金融・保険業	38,170.0	27,405.9
（８）不動産業	48,488.1	58,721.7
ａ．住宅賃貸業	40,550.1	51,444.5
ｂ．その他の不動産業	7,576.5	7,226.2
（９）運輸業	24,577.6	23,317.2
（１０）情報通信業	13,358.8	28,133.4
ａ．通信業	4,876.1	12,356.8
ｂ．放送業	1,021.9	1,651.0
ｃ．情報サービス・映像文字情報制作業	7,816.6	14,337.0
（１１）サービス業	72,051.8	92,079.6
ａ．公共サービス	17,881.9	27,557.6
ｂ．対事業所サービス	20,120.5	34,543.2
ｃ．対個人サービス	35,331.8	29,925.8
２．　政府サービス生産者	39,601.3	46,067.3
（１）電気・ガス・水道業	2,137.6	2,885.4
（２）サービス業	11,933.8	12,151.3
（３）公務	25,527.6	31,036.4
３．　対家計民間非営利サービス生産者	8,123.9	11,369.1
（１）教育	4,227.2	5,002.9
（２）その他	3,895.8	6,354.1
小計	444,102.0	502,387.3
輸入品に課される税・関税	3,704.2	4,893.8
（控除）総資本形成に係る消費税	2,479.1	2,585.2
国内総生産（不突合を含まず）	444,982.2	504,761.8
統計上の不突合	1,797.7	4,680.8
国内総生産	446,779.9	509,442.5

（注）統計上の不突合は連鎖方式での計算ができないため、「国内総生産」－「国内総生産（不突合を含まず）」により求めている。

Figure 2.2 Example of GDP Production Approach Released by Japanese Government almost 340 percent while the lowest Japan still had 21 percent volatility in last two decades.

Table 2.1 Deflator of Sampled Countries/Regions

Year	Japan	China	Korea	Hong Kong SAR
1990	105.865	100	47.128	67.608
1991	108.624	106.82	51.598	73.788
1992	110.349	115.535	55.594	81.092
1993	110.832	133.123	59.039	88.077
1994	110.959	160.59	63.823	93.644
1995	110.154	182.503	68.252	97.521
1996	109.541	194.43	71.157	103.259
1997	110.193	197.596	74.049	109.207
1998	110.133	195.824	77.468	110.539
1999	108.73	193.329	76.55	106.012
2000	107.373	197.253	77.382	102.413
2001	106.087	201.291	80.207	100.596
2002	104.443	202.491	82.661	97.174
2003	102.652	207.71	85.468	91.336
2004	101.263	222.048	88.018	88.057
2005	99.996	230.742	88.926	87.924
2006	98.875	239.77	88.802	87.454
2007	97.955	258.623	90.931	90.198
2008	96.715	278.786	93.619	91.354
2009	96.232	278.574	96.935	91.011
2010	94.152	297.986	100	91.257
2011	92.406	322.194	101.585	96.577
2012	91.545	329.909	102.645	100.000
2013	91.043	337.278	103.521	101.705
2014	92.557	340.055	104.103	104.714
Highest/Lowest	1.2188	3.4006	2.2089	1.6350

Data source: from World Economic Outlook Database, International Monetary Fund

2.2.3 Input-Output Analysis

GDP statistics is definitely not an easy job and the accounting framework has to meet several certain requirements. To meet all these requirements simultaneously, System of National Account (SNA) (2008) is introduced under the auspices of the United Nations, the European Commission, the Organisation for Economic Co-operation and Development, the International Monetary Fund and the World Bank Group to provide a statistical framework that highlights a comprehensive, consistent and flexible set of macroeconomic accounts for policymaking, analysis and research purposes.

In fact, SNA does not only provide reliable macroeconomic data source but also provide efficient methodologies for macroeconomic analysis. Input-output analysis is just one of popularly used methodologies.

Input-output Analysis is the name given to an analytical framework developed by Wassily Leontief in the late 1930s, in recognition of which he received the Nobel Prize in Economic Science in 1973. The term “inter-industry analysis” is also used, since the fundamental purpose of the input-output framework is to analyze the interdependence of industries in any economy.

In its most basic form, an input-output model consists of a system of linear equations, each one of which describes the distribution of an industry’s product throughout the economy. Most of the extensions to the basic input-output framework are introduced to incorporate additional details of economic activity, such as international and interregional flows of products and services, to accommodate limitations of available data or to connect input-output models to other kinds of economic analysis tools.

The fundamental information used in input-output analysis concerns the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself and others, considered as consumers. This basis information from which an input-output model is developed is contained in an inter-industry transactions table. The rows of such a table describe the distribution of producer’s output throughput the economy. The columns describe the composition of inputs required by a particular industry to produce its output. These inter-industry exchanges of goods constitute the shaded portion of the table depicted in Table 2.2. The additional columns, labeled Final Demand, record the sales by each sector to final markets for their production, such as personal consumption purchases and sales to the federal government. For example, electricity is sold to businesses in other sectors as an input to production (an inter-industry transaction) and also to residential consumers (a final demand sale). The additional rows, labeled Value Added, account for the other (non-industrial) inputs to production, such as labor, depreciation of capital, indirect business taxes, and imports[10]. From Table 2.2 input-output model can be written as below equations:

$$\begin{array}{l} x_{11}+x_{12}+\ldots+x_{1n}+y_1=x_1 \\ x_{21}+x_{22}+\ldots+x_{2n}+y_2=x_2 \\ \quad\quad \vdots \\ x_{n1}+x_{n2}+\ldots+x_{nn}+y_n=x_n \end{array} \quad (2.5)$$

Input \ Output		Producers As Consumers				Final Demand				Gross Output
		Dept 1	Dept 2	…	Dept n	Consuming	Investment	Export	Final Demand	
Producers	Dept 1	x_{11}	x_{12}	…	x_{1n}	c_1	k_1	e_1	y_1	x_1
	Dept 2	x_{21}	x_{22}	…	x_{2n}	c_2	k_2	e_2	y_2	x_2
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	Dept n	x_{n1}	x_{n2}	…	x_{nn}	c_n	k_n	e_n	y_n	x_n
Value Added	Labor	w_1	w_2	…	w_n					
	Business taxes	m_1	m_2	…	m_n					
	Value Added	v_1	x_2	…	x_n					
Gross Input		x_1	x_2	…	x_n					

Table 2.2 Simplified Input-Output Transactions Table

Above row equation can be written into equation (2.6):

$$\sum_{j=1}^{n} x_{ij} + y_i = x_i \quad (i=1, 2, \ldots, n) \quad (2.6)$$

Leontief defined a_{ij} as direct input coefficient in below equation (2.7).

$$a_{ij} = x_{ij}/x_j \quad (2.7)$$

Thus, equation (2.8) was got after combination of equation (2.6) and (2.7) as below:

$$\sum_{j=1}^{n} a_{ij}x_j + y_i = x_i \quad (i=1, 2, \ldots, n) \quad (2.8)$$

Equation (2.8) can be written into matrix equation as:

$$AX + Y = X \quad (2.9)$$

A: direct input coefficient matrix.
X: gross output column vector.
Y: final demand column vector.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \quad Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}$$

Equation (2.10) can be derived from equation (2.9) as below:

$$X = (I - A)^{-1} \cdot Y \quad (2.10)$$

$(I - A)^{-1}$ is called Leontief inverse matrix and it explains relationship between final demand and gross output. Theoretical research indicates Leontief inverse matrix is equal to total requirement coefficient matrix plus a unit matrix.

$$L = (I - A)^{-1} = (B + I) = \begin{bmatrix} l_{11} & l_{12} & \cdots & l_{1n} \\ l_{21} & l_{22} & \cdots & l_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ l_{n1} & l_{n2} & \cdots & l_{nn} \end{bmatrix} = \begin{bmatrix} b_{11}+1 & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22}+1 & \cdots & b_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn}+1 \end{bmatrix} \quad (2.11)$$

L: Leontief inverse matrix (total requirement matrix).
B: total consumption coefficient matrix.
l_{ij}: total requirement coefficient.
b_{ij}: total input coefficient.

By use of equation (2.10) and (2.11), if 1 unit more final demand is required in Dept 1, it is possible to calculate how much gross output will be produced. For example, if y_1 is set as 1 when other final demand is set as 0, gross output will be as equation (2.12):

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} b_{11}+1 & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22}+1 & \cdots & b_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn}+1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ \vdots \\ 0 \end{bmatrix} = \begin{bmatrix} b_{11}+11 \\ b_{21} \\ \vdots \\ b_{n1} \end{bmatrix} \quad (2.12)$$

That means gross output is equal to sum of first column of Leontief inverse matrix. It is clear that Dept 2's 1 unit more final demand will need gross output with sum of second column of Leontief inverse matrix and so on.

Regarding Leontief inverse matrix, above equation (2.11) is just a simplified case because it does not consider import trading. If import factor is considered, Japanese 2011 Input-output Tables Explanatory Report indicates that equation (2.13) is popularly used in Japan to make relevant analysis:

$$L = (I - (I - \widehat{M}) \cdot A)^{-1} \quad (2.13)$$

$$\widehat{M} = \begin{bmatrix} m_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & m_n \end{bmatrix} \quad (2.14)$$

where m_i indicates import coefficient of Dept i (i=1,2,⋯, n) which indicates ratio between import value and sum of final demand.

Leontief inverse matrix is always called matrix multiplier and input-output multiplier because it looks like a multiplier. Leontief's input-output research told us that even though only additional final demand of Dept i is required, every other department has to produce, too. This is the mechanism which can explain the relationship between container throughput and industries. For example, though non-physical industries do not generate container throughput directly, their final demand's fluctuation will have influence on physical industries' output and finally increase or decrease container throughput.

Most countries release national input-output transactions table five years once a time. Figure 2.3 is an example released by Japanese government for the year of 2011.

Many researchers explored the extension of input-output framework to more detailed analysis which was associated with industrial production, including some of the complication that could arise when measuring input-output transactions in physical units of production rather than in monetary terms of the value of production.

Input-output analysis is a structural analysis method. It is a reflection of interdepartmental connection by multi sector design compared with aggregate analysis. Though GDP is one of the most important indicators of macro economy, GDP fails to indicate different commodities' properties and take all the products as a single product. The economic analysis is obviously not enough if only GDP data is grasped. Structural analysis can include more factors for more comprehensive analysis.

Input-output analysis is also one of the methodologies SNA provides. Within SNA 2008 edition, Chapter 28 "Input-output and other matrix-base analyses" introduced this methodology in detail and included example of Social Accounting Matrices.

2.3 Literature on Container Throughput

表１－２　平成23年（2011年）産業連関表

購入者価格評価表(13部門分類)

（単位：10億円）

	中間需要 01 農林水産業	02 鉱業	03 製造業	04 建設	05 電力・ガス・水道	06 商業	07 金融・保険	08 不動産	09 運輸・郵便	10 情報通信	11 公務	12 サービス
中間投入 01 農林水産業	1,567.5	0.1	9,417.2	127.9	0.0	20.0	0.0	0.4	3.4	0.0	2.9	2,305.0
02 鉱業	0.3	2.1	17,712.7	499.5	7,727.6	0.0	0.0	0.0	0.1	0.0	0.5	1.5
03 製造業	3,447.6	88.4	147,113.4	18,890.1	2,519.3	4,013.1	1,203.1	282.8	8,475.5	3,014.4	3,080.9	37,878.2
04 建設	70.6	6.1	1,340.6	74.1	1,179.5	644.8	188.4	3,155.7	687.0	322.8	810.3	1,293.5
05 電力・ガス・水道	129.0	29.5	5,433.5	279.2	2,867.1	2,104.8	181.0	420.8	676.7	399.0	538.5	4,649.1
06 商業	0.0	0.0	0.0	0.0	0.0	988.9	0.0	0.0	0.0	0.0	0.0	0.0
07 金融・保険	70.6	26.9	1,667.2	705.5	415.8	1,595.8	2,012.3	5,383.1	995.8	219.7	1,629.2	1,858.0
08 不動産	25.5	7.5	590.0	243.7	173.2	3,217.4	631.5	1,862.0	1,016.7	1,214.7	61.2	2,961.1
09 運輸・郵便	353.7	191.8	2,935.0	1,154.0	216.7	5,088.5	1,039.6	155.6	4,958.7	1,012.3	1,271.0	3,668.2
10 情報通信	45.7	8.3	2,051.8	516.6	457.1	3,905.2	1,946.6	315.3	588.9	7,123.2	1,179.0	8,303.4
11 公務	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12 サービス	317.2	53.1	18,174.6	5,086.0	3,124.1	7,262.1	3,640.9	2,168.7	6,185.2	8,276.3	3,864.6	21,267.1
13 分類不明	169.9	6.0	902.0	825.7	112.9	702.6	133.2	363.1	393.5	317.0	35.2	1,338.8
内生部門計	6,197.6	419.9	207,337.6	28,802.3	18,795.4	29,543.2	10,976.6	13,807.4	23,981.4	21,899.5	12,473.3	85,523.9
粗付加価値 家計外消費支出	75.6	36.5	3,319.8	989.2	305.0	2,111.2	952.2	272.1	823.8	881.5	397.1	3,493.0
雇用者所得	1,352.3	143.6	43,270.0	18,409.8	2,498.2	37,017.8	9,836.1	3,947.9	14,100.8	10,648.0	14,501.4	92,516.8
営業余剰	2,857.9	44.5	7,886.2	1,031.4	-2,386.1	15,042.5	7,138.1	29,708.2	2,228.6	7,885.4	0.0	13,887.1
資本減耗引当	1,723.1	74.2	17,789.2	1,654.5	5,069.9	6,512.9	3,493.6	19,495.2	5,328.2	3,978.6	11,911.0	21,802.5
間接税（関税・輸入品商品税を除く。）	524.7	42.3	10,487.2	1,947.0	1,140.5	3,480.1	545.2	3,998.1	1,996.4	889.5	122.5	6,714.2
（控除）経常補助金	-695.2	-0.9	-185.6	-299.7	-268.3	-51.9	-847.8	-41.4	-225.1	-2.2	0.0	-979.1
粗付加価値部門計	5,838.4	340.1	82,566.9	23,712.2	6,959.2	64,112.7	21,117.3	57,380.1	24,232.6	24,260.8	26,931.9	137,434.4
国内生産額	12,036.0	760.0	289,904.5	52,514.5	25,754.7	93,655.8	32,093.9	71,187.5	48,234.0	46,160.3	39,405.2	222,958.2

	13 分類不明	内生部門計	最終需要 家計外消費支出	民間消費支出	一般政府消費支出	国内総固定資本形成	在庫純増	国内最終需要計	輸出計	最終需要計	需要合計	（控除）輸入計	国内生産額
01 農林水産業	0.0	10,881.0	63.4	3,389.1	0.0	168.3	246.8	3,869.9	47.9	3,917.8	14,598.8	-2,562.8	12,036.0
02 鉱業	0.5	24,092.8	-5.4	-6.1	0.0	-7.0	-42.0	-58.8	35.6	-23.2	24,069.6	-23,309.6	760.0
03 製造業	454.8	193,589.1	1,639.1	55,177.6	242.9	31,026.7	598.3	90,241.8	54,437.7	144,679.5	338,268.6	-48,364.1	289,904.5
04 建設	0.0	9,773.2	0.0	0.0	0.0	42,741.3	0.0	42,741.3	0.0	42,741.3	52,514.5	0.0	52,514.5
05 電力・ガス・水道	64.9	17,773.1	7.9	8,201.9	-261.4	0.0	0.0	7,948.4	35.3	7,983.7	25,756.8	-2.1	25,754.7
06 商業	76.1	35,355.0	1,552.4	43,597.2	9.8	6,388.2	150.7	51,698.2	7,591.5	59,289.7	94,644.7	-988.9	93,655.8
07 金融・保険	24.1	16,604.0	0.2	15,558.2	0.0	0.0	0.0	15,558.3	838.2	16,396.5	33,000.6	-906.6	32,093.9
08 不動産	195.3	11,901.6	0.0	59,204.5	61.3	0.0	0.0	59,265.8	21.8	59,287.6	71,189.2	1.7	71,187.5
09 運輸・郵便	397.5	31,107.0	399.2	13,784.9	-53.2	661.2	37.9	14,830.0	5,759.5	20,589.5	51,696.5	-3,462.5	48,234.0
10 情報通信	212.2	25,459.6	161.4	12,722.9	35.8	8,217.0	-11.8	21,126.1	289.7	21,415.8	46,875.4	-715.2	46,160.3
11 公務	1,136.6	1,136.6	0.0	1,115.2	37,153.5	0.0	0.0	38,268.6	0.0	38,268.6	39,405.2	0.0	39,405.2
12 サービス	449.5	80,269.4	9,815.0	70,057.3	61,547.9	2,188.8	0.0	143,610.3	1,883.7	145,493.9	225,763.3	-2,805.1	222,958.2
13 分類不明	0.0	5,027.3	0.0	18.9	0.0	0.0	0.0	18.9	3.7	22.6	5,049.8	-39.5	5,010.3
内生部門計	3,011.5	462,769.6	13,833.3	282,821.4	98,736.5	91,384.4	979.8	489,118.8	70,944.6	560,063.3	1,022,832.9	-83,158.1	939,674.9
家計外消費支出	10.3	13,633.3											
雇用者所得	178.7	248,421.0											
営業余剰	1,482.2	86,806.1											
資本減耗引当	275.0	99,708.0											
間接税（関税・輸入品商品税を除く。）	46.5	31,934.1											
（控除）経常補助金	-0.0	-3,597.2											
粗付加価値部門計	1,998.7	476,905.3											
国内生産額	3,010.3	939,674.9											

（注）１　四捨五入していることから、内訳は必ずしも合計と一致しない。

２　各取引額は、消費税込みである。ただし、輸出は免税であるため消費税を含まない。

３　国内最終需要計には、消費及び投資のほか、「調整項」の額も含んでいるため、内訳の合計と一致しない。

Fig 2.3 Japanese 2011 Input-output Table by 13 Industries

Container throughput is one of the hot topics in container transport field since it demonstrates the demand of container terminal investment. However, most researches focused on container throughput forecasting and adopted GDP data integrally without any reasoning while GDP data was taken for granted to be positively correlated with container throughput without any discussion on container throughput generation mechanism.

2.3.1 Container Throughput Generation Mechanism

There are a lot of container throughput classification methods, for example, in terms of container types, general, open top, flat rack and other special container's throughput, or in terms of cargo type, general cargo, reefer cargo, dangerous cargo throughput and so on. For every method, it describes one of container throughput generation mechanisms and every generation mechanism decides standard of data collection as well as container throughput structure specifically.

The most popular classification method divides national or regional container throughput into three segments including domestic, international and international transshipment segment in terms of trade nature as function (2.15):

$$\mathrm{CONT} = \mathrm{DC} + \mathrm{IC} + \mathrm{TC} \tag{2.15}$$

CONT: national or regional gross container throughput.
DC: domestic container throughput.
IC: international container throughput.
TC: international transshipment container throughput.

Domestic container transport is to meet part of domestic trade demand so that domestic container throughput is a mirror of domestic trade when international container throughput roughly reflects scenario of international trade, but transshipment business is an exception.

With the development of container transport, especially vessel's large-sized trend, large container vessels can only serve several hub ports with deep draft and giant gantries so that transshipment gradually becomes a typical characteristic of container transport compared with other maritime transport mode. In order to increase throughput scale as well as revenue, hub ports try to attract more cargo transshipped through its own terminals. However, transshipment service handles the business which basically meets the demand of cargo manufacturing and consuming countries but not hub's local economic demand, it is not connected with local trade demand and macro economy.

Obviously, the economic facts or generation mechanisms behind above three segments are completely different. Many countries and international organizations release gross container throughput while some countries only divide the same into domestic and international container throughput. In many cases, international transshipment business is dealt as international business unless transshipment throughput volume is big enough and released individually. For example, Korea releases its transshipment volume due to big share of transshipment business but China does not release same kind of data.

2.3.2 Container Throughput and Containerization

It is obvious that container transport is just one of the transport modes. Bulk carriers and tankers carry most merchandise in weight wise. However, container transport and throughput climbs rapidly with the development of containerization. In general speaking, the higher containerization ratio is, the more container throughput is. Especially, container vessel's large-sized trend drives drastic transshipment business development and pushes container throughput into a higher level. A lot of empirical analysis demonstrated that container throughput was highly correlated with global or regional seaborne trade.

However, containerization ratio is closely connected with commodity. For example, coal and iron ore are generally carried by bulk and their containerization ratio can be neglected while diamond and art collections are carried by air due to their value and security demand. Basically, containerization provides cost advantage to the cargo with medium unit value. The cargo with too high or too cheap unit price will not be carried by containers to generate container throughput. Basically, transport mode can be roughly judged by cargo's description and characteristics.

2.4 Literature on Econometrics

2.4.1 Econometrics Methodology

Hendry (1980) put forward concept of data generating process in his "Econometrics-Alchemy or Science?" and proposed "rigorously tested models, which adequately described the available data, encompassed precious finds and were derived from well based theories would greatly enhance any claim to be scientific".

Katarina Juselius (2009) further supported above proposal and wrote "The statistical model ties economic theory to the data when it nests both the data-generating process and the theoretical model".

Liu (2012) pointed out that the Hendry's ideas could be understood as the trinity of economic theory, observed data and econometric model but there was no absolute consistence among theory, data and model. Model is just an approximation of reality and is restricted by limited data source. What scholars can do is just try to match the economic facts behind model and limited data as much as possible.

However, the general methodology for simple system is not applicable to macroeconomic analysis since macro economy is an open complex system. It is necessary to decompose the complex system into simple systems in the modeling process. Tian et al. (2009) proposed specific methodology to decompose complex system into simple system to analyze major trend by use of econometric models before integrate all the parts with the thought of integration, so as to achieve the analysis of complex system.

Meanwhile, pure quantitative analysis cannot answer all the questions and integrated analysis combined by qualitative and quantitative analysis is necessary for complex system. Cao (2006) pointed out "With respect to complex system problem, traditional reductionism approach is usually ineffective owing to the complexity of related system, while qualitative-quantitative integration provides methodological guide for the modeling of complex system problem. For example, due to the complexity of economic system, macroeconomic prediction requires qualitative-quantitative integration in economic modeling in order to take comprehensive use of qualitative and quantitative knowledge and information".

There are lots of qualitative and quantitative analysis methods just like scenario analysis, Delphi method, regression analysis, time-series analysis and so on which can be chosen to achieve integrated analysis.

Of course, the debate on econometrics has always existed from the beginning and many researchers assigned the abuse of econometrics as an important factor in the question on the scientific nature of econometrics. It is undeniable that there were lots of researches with consistent statistical significance, perfect test result but poor economic sense. Sometimes variables and data were selected arbitrarily and modelling did not conform to the economic theory or even contrary to common sense.

Just like Thomas Piketty (2014) described that too much energy had been and still was being wasted on pure theoretical speculation without a clear specification of the economic facts one was trying to explain or the social and political problems one was trying to resolve.

2.4.2 Regression Analysis

Regression analysis is used to understand which among the independent variables are related to the dependent variable, and to explore the mathematic forms of these relationships to make prediction and forecasting widely. Correlation analysis is used to quantify the association between two continuous variables while enough high correlation coefficient is a necessary condition for regression analysis.

Anyway, regression analysis is different from correlation analysis. Correlation indicates the strength of association between variables. As opposed to, regression reflects the impact of the unit change in the independent variable on the dependent variable. In correlation, there is no difference between dependent and independent variables i.e. correlation between x and y is same the correlation between y and x.

Generally, neither regression nor correlation can be interpreted as establishing cause-and-effect relationships. They can only indicate how or to what extent variables are associated with each other. Any conclusions about a cause-and-effect relationship must be based on the judgment of the analyst.

J. Scott Armstrong (2011) warned in his "Illusion in Regression Analysis" with "Do not use regression to search for causal relationships. And do not try to predict by using variables that were not specified in the a priori analysis. Thus, avoid data mining, stepwise regression, and related methods". Meanwhile he still admitted "We have ample evidence that regression analysis often provides useful forecasts. Regression-based prediction is most effective when dealing with a small number of variables, large amounts of reliable and valid data, where changes are expected to be large and predictable, and when using well-established causal relationships - such as the elasticities for income, price, and advertising when forecasting demand".

Freedman (1991) pointed out that an elaborate theory was necessary to specify the variables in the system, their causal interconnections, the functional form of the relationship and the statistical properties of the error terms-independence, exogeneity, etc. in order to derive a regression model. Freedman's argument was similar to Armstrong's which meant causality was not a sufficient condition but a necessary condition for sound regression analysis.

In general, regression analysis has very strict limitations. It has to examine the relationship between variables, find enough high-quality historic data and keep a stable system structure to ensure a sound regression.

2.5 Literature on Container Throughput Analysis

2.5.1 Relationship between Macro Indicators and Container Transport

In the regression approach, most researches used GDP as one of the independent variables to make the analysis of container transport.

a. Review of Maritime Transport 2013

UNCTAD Review of Maritime Transport (2013) concluded "For a long time, containerized trade flows could be predicted by looking at the performance of world GDP with the multiplier effect of the container volume growth ranging between three to four times the GDP growth". Interestingly, the same annual report further pointed out "This ratio is currently being questioned with some observers arguing that it is no longer a precise predictor of container-demand growth since other factors are also at play (Containerisation International, 2013a). These factors include the rate of off-shoring of manufacturing, the extent of containerization of bulk cargoes, the goods-versus-services composition and the manufactured-versus-commodities share of countries".

b. America's Container Ports (2011)

The report introduced that containers carried a wide variety of commodities, from sweaters, blouses, and flat-screen televisions to computer equipment, wood and paper products.

Growth in economic activity and rises in exports and imports generally resulted in increased demand for freight transportation services by all modes of transportation. Because most U.S. overseas merchandise trade (over 66 percent by value and 99 percent by weight) moved by ocean vessel (USDOC CB 2010), the Nation's container ports were immediately impacted by swings in economic activity.

A comparison of the year-on-year percent changed between U.S.-loaded container TEUs and real GDP showed a correlation between container maritime industry trends and general economic conditions. This comparison showed the effect that economic cycles had on U.S. container trade, as evidenced by declines in TEUs during the 2001 and 2008–2009 recessions. As data showed, the container trade trend was more volatile than the GDP trend.

c. Maritime Economics 3rd edition

Martin Stopford (2009) described in his textbook for container business as "So we might as well accept at the outset that this is a highly complex business and analysts must expect problems getting to the bottom of it. A good starting point is the relationship between container cargo and world economic activity". In his classical textbook, Professor exhibited linear regression analysis between world seaborne trade and world GDP and he also surprised to find correlation coefficient is 0.99.

2.5.2 Macro Indicators and Container Throughput

d. Forecasting the Demand of Container Throughput in Indonesia

Syafi'i et al. (2005) presented forecasting demand of container throughput in Indonesia. The analysis was done in multivariate autoregressive model which could be written as a vector error correction model as the following formula:

$$Y_t = \prod_1 Y_{t-1} + \cdots + \prod_k Y_{t-k} + \Phi D_t + \varepsilon_t \tag{2.16}$$

$Y_t = (y_{1t}, \dots \dots, y_{kt})$.

$\prod_i$: K x K coefficient matrix.

k: the order of the vector autoregressive model.

ε_t: denoted residual error-term.

In this study, k was set as 5, Y_t = (Container, GDP, Population, Export, Import). The forecasting indicated container throughput increased from 4,982,755 TEU in 2003 to 18,712,042 TEU in 2015 with the average annual growth 11.69% (the exact amount in 2015 was 12,031,700 TEUs in UNCTAD database). GDP, export and import trade data were used in this study to make analysis on container throughput.

e. Competitiveness of Japanese Container Ports Reconsidered

Tsumori Takayuki (2011) analyzed source of competitiveness of Japanese main container ports, then specified the course of suitable container port policy in Japan. The paper clearly pointed out that Japanese main container ports could not depend to increase container cargoes throughput on only efficient stevedoring system in port and national government should, at first, support to strengthen supply chain networks as short-term policy and secondly promote to reagglomerate or regenerate the cluster of manufacturing industry as long-term policy.

f. Predicted Future Trends of Container Cargo Flow with Consideration of Economic Partnership progress

Hironao Takahashi (2009) examined container throughput analysis methodology and pointed out that there were a lot of cases in which container throughput had relative strong correlation with national or regional GDP, but it was difficult to grasp policy enforcement effect as assumed in his study since explanatory variables were extremely limited by GDP or such kind of macro indicators.

g. The Correlation Analysis on Port Container Throughput and Main Macroeconomic Indices

Liu Bing et al. (2002) made use of linear regression model to make the analysis on Chinese container throughput against GDP, fixed asset investment, interest rate and international trade amount.

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \mu \quad (2.17)$$

Y: container throughput
X_1: international trade value
X_2: GDP
X_3: fixed asset investment
X_4: loan interest rate
μ: residuals

Liu found the container throughput correlated with international trade and fixed asset investment positively but with GDP and loan interest rate negatively at first. After t-test was done, the study concluded that only international trade was found to be correlated and all other three factors, GDP, fixed asset investment and interest rate were not correlated with container throughput.

h. Causality between Port Traffic Volume and Regional economy: VAR Approach

Mo Soo-Won (2013) investigated causality between port traffic volume and gross regional domestic product (GRDP) in vector autoregression technique. It was confirmed that there was a possibility that causality between traffic volume and local economy varied in every area while the movement of correlation coefficient of the two variables was also varied in different area. However, correlation coefficient was high in all area to indicate the existence of correlation between port traffic volume and GRDP.

It was very interesting that further research found that local economy was not appropriate to explain traffic volume in most of the cases, whereas traffic volume was an important variable to explain local economy.

i. Econometric Analysis Based on the Throughput of Container and Its Main Influential Factors

Jiang Jian et al. (2007) used binary linear regression model to make the econometric analysis of container throughput, local GDP and international trade volume in value basis.

$$Y = C_1 + C_2X_1 + C_3X_2 + \varepsilon \quad (2.18)$$

Y: container throughput
X_1: GDP
X_2: international trade value
ε: residuals

Authors found local container throughput only correlated with international trade volume but did not correlate with local GDP.

j. A Comparison of Traditional and Neural Networks Forecasting Techniques for Container Throughput at Bangkok Port

Veerachai Gosasang et al. (2011) pointed out "The economic expansion increases the volumes of containers at Bangkok Port and the growth of this container throughput is one of the most important determinants of the large investment for container terminal. Therefore, the forecasting accuracy of the future throughput is crucial to both of private sectors and government offices for planning and managing their future development." Authors examined forecast performance between neural network and linear regression model by use of the root mean squared error (RMSE) and the mean absolute error (MAE). The independent variables in linear regression model included national GDP, world GDP, exchange rate, population together as well as other macroeconomic indicators.

k. A Study on Correlation Model of Seaport Container Throughput and Gross Domestic Product

Zhu Xiaomeng (2014) pointed out that seaport transport industry of different countries depended not only on the own GDP, but also their development stage of industrialization, natural endowment, economic growth mode and the position in the chain of global economic integration after making grey correlation degree of GDP and its three factors (consuming, investment and net export) with container throughput. The paper derived the formula on the elasticity coefficient of seaport container throughput relating to GDP and its three factors. Zhu took the natural logarithm of GDP and container throughput data series processed by Hodrick-Prescott filter while making correlation analysis by use of timeseries-causality method. Container throughput was the complex exponential function of GDP data as below:

$$\mathrm{CT} = \mathrm{e}^{\mathrm{tc}} = \mathrm{e}^{f(tg)} \quad (2.19)$$

CT: container throughput
tc: the natural logarithm of container throughput time series trend component
tg: the natural logarithm of GDP time series trend component

l. Changes in Southeast Asia Container Handling Volumes

Masayoshi Kubo et al. (2000) attempted to show the effects of the decrease in the amount of cargo traffic due to the currency crisis occurred on 1997 in the Southeast Asia. The paper described "In order to explain the expansion of the economies in the Southeast Asia, it is necessary to focus on the macroeconomic factors. Thus, the role played by foreign trade on the GDP increase, is fundamental to understand the relation between trade activities and the economic growth".

This is the first literature found in this research which clearly clarified the using of real GDP data. The research established relation between the GDP and the container throughput by use of linear and logistics regression model to estimate the growing tendency of container cargo in Southeast Asia during the 1998 to 2010 period.

However, the research showed that many countries' coefficients of determination between container throughput and GDP were higher than 0.90 or even 0.99. For example, the coefficient between Indonesia's container throughput and GDP was 0.9944 from 1975 to 1997 when the sum of China mainland and Hong Kong's container throughput had high coefficient of determination 0.9986 with China mainland's GDP.

In a word, though other macro indicators were simultaneously adopted in various analyses, for example, population and international trade volume, most researches made use of GDP data directly and integrally in regression models. In other word, GDP was used as symbol of macro economy to analysis the national or regional container throughput in most cases.

2.5.3 Transshipment Business

There was lot of researches specific for transshipment business but mainly focused on the competition between hub ports and container network design (Bart W. Wiegmans et al. (2008)). Only a few papers discussed transshipment demand.

Min Ju Bae et al. (2013) identified port capacity, price, transshipment level and port congestion as the primary factors concerning the transshipment demands of the port and its rivals. In particular, Bae constructed a linear demand function for container port's transshipment traffic and assumed the transshipment container demand depended only on port's handling capability and aggregate contribution of shipping lines' port calls in the stipulated period of time.

Christopher et al. (2008) identified the transshipment container demand from gateway container demand and developed the game theoretic best response framework for building additional capacity.

Christopher pointed out the strategic game based on current activities did not support the high level investment and if too much development region-wide, a surplus of port capacity could drive prices to marginal cost at all ports, leaving all ports unable to recover their investments.

The typical case observed was the biggest container carrier, Maersk moved her transshipment hub from Singapore to Tanjung Pelepas, Malaysia in 2000 after she failed in price negotiation with PSA, administrator of Port of Singapore. Malaysia’s GDP scale was almost same as Singapore while GDP per capita was only one-fifth of Singapore’s in 2000. However, Tanjung Pelepas became top 18th container port in 2014 with container throughput over 8.5 million TEUs compared with 420,000TEUs in 2000. This case clearly told us the transshipment business was not closely connected with hub’s economic development.

2.5.4 RWI/ISL Container Throughput Index

In the final stage of this study, it was found that not only researches from world economy to container throughput were made but also other frontier study was made from container throughput to world economy. RWI/ISL Container Throughput Index is a successful try and unique index for container throughput we found in shipping field.

Basically, the common global economy indicators show a reasonably significant lag in publication. For example, IMF or OECD only releases world merchandise trading data three months before. As Background Information Report RWI/ISL Container Throughput Index pointed out that if the world trading collapse during the financial and economic crisis 2008/09 was repeated today, it would be completely in a “statistical shadow”. At that time, the international exchange of goods declined by more than 15% between November 2008 and February 2009.

Thus, RWI and ISL are jointly publishing a monthly index for global container throughput (See Figure 2.5) since 2012 which aims to provide reliable conclusions on short term trends in worldwide economic activity. The RWI/ISL Container Throughput Index uses the fact that global economic momentum is the key driving force for all throughput activities while international trade is primarily handled by ships and containers, which means the container throughput in ports is an important indicator of global trade.

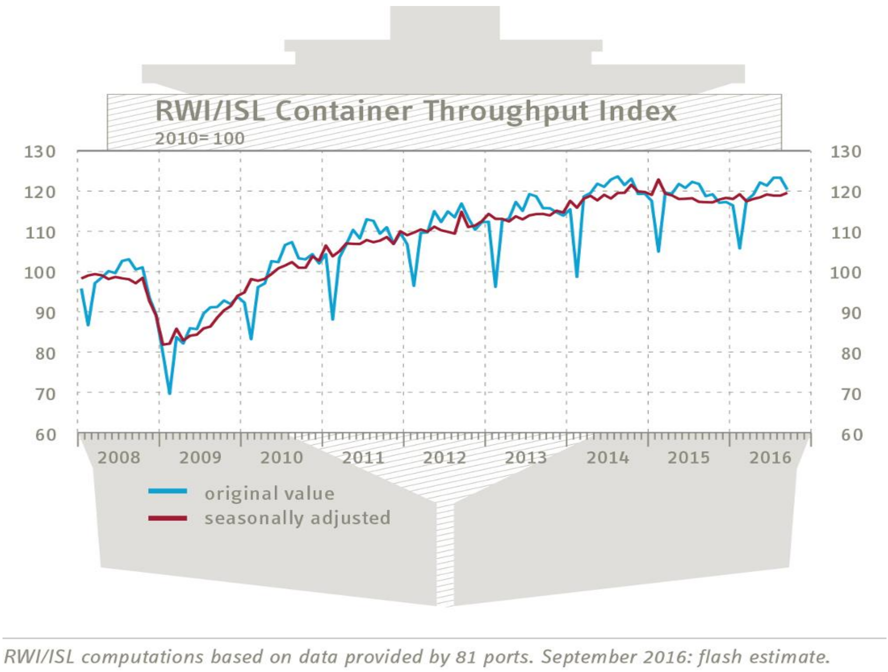


Figure 2.5 RWI/ISL Container Throughput Index (from website of ISL)

Calculating the Container Throughput Index starts about 25 days after the end of each month with a flash estimate. A month later, the data of more than 65 ports are usually available for the previous month. Thus, in additional to the initial estimate for the actual month, a correspondingly revised value for the previous month is published. This makes the Container Throughput Index to a significantly faster instrument than other used indicators of the international exchanges of goods.

Calculations since 2007 show that the Container Throughput Index is very closely correlated with the data on world trade, which are published by the IMF. In particularly, during the financial and economic crisis in 2008/2009, the index provided reliable data. As the Germany economy is heavily export-oriented, the assessment of the international economy is an essential basis for analysis.

ISL has been promptly recording the monthly container throughput at a large number of seaports for several years now. Overall, the indicator includes the details from 81 seaports, which handle approximately 60% of world container throughput.

Initial container traffic details are obtained approximately 15 days after the end of a month. This is when the details from Singapore and Hong Kong as well as others are published. As these ports count among the world's most important throughput hubs (See Table 2.3), the initial tendencies can be clearly seen at this time. About 10 days later, the details are available for around 15 seaports, but this sometimes changes from month to month. These provide a sufficiently broad basis to create a reliable estimate for the Container Throughput Index that will be published. Normally the details of more than 65 ports from two months ago are available one month later, so that just a few values still have to be estimated. A revised value for the previous months can be published together with the initial estimate for the month that has just passed. Previous experience has shown that this value changes slightly during the following months.

Table 2.3 Container Throughput of 20 Largest Container Ports in the World

Seaport ranking (country)		2011	2010	Change in %	Index
1	Shanghai (China)	31,393	29,003	8.2	Yes
2	Singapore (Singapore)	29,931	28,431	5.3	Yes
3	Hong Kong (China)	24,373	23,698	2.8	Yes
4	Shenzhen (China)	22,499	22,341	0.7	Yes
5	Busan (South Korea)	16,164	14,185	14.0	Yes
6	Ningbo (China)	14,601	13,071	11.7	Yes
7	Guangzhou (China)	14,129	12,487	13.1	Yes
8	Qingdao (China)	13,199	12,013	9.9	Yes
9	Dubai (UAE)	13,000 [a]	11,576	12.3	No
10	Rotterdam (Netherlands)	11,902	11,146	6.8	No
11	Tianjin (China)	11,494	10,076	14.1	Yes
12	Kelang (Malaysia)	10,200 [a]	8,870	15.0	No
13	Kaohsiung (Taiwan)	9,636	9,181	5.0	Yes
14	Hamburg (Germany)	9,100 [a]	7,898	15.2	Yes
15	Antwerp (Belgium)	8,638	8,468	2.0	No
16	Los Angeles (USA)	7,941	7,832	1.4	Yes
17	Tanjung Pelepas (Malaysia)	7,200 [a]	6,299	14.3	No
18	Xiamen (China)	6,454	5,813	11.0	Yes
19	Dalian (China)	6,158	5,784	6.5	No
20	Long Beach (USA)	6,061	6,264	-3.2	Yes

Source: ISL seaport database, in 1000 TEU, issued February 2012 - [a] Provisional. (Background Information Report of RWI/ISL Container Throughput Index)

In order to create the index, the container throughput of the monitored seaports is initially summed since all of the details are compiled using the global uniform measure of Twenty-foot Equivalent Units (TEU). An index based on 2008=100 was derived from the result afterwards. The indicator was calculated from 2007 onwards. The Container Throughput Index is adjusted seasonally and for working days using the Census X12 method. However, the numbers determined in this way will also include some irregular fluctuations, such as those resulting from unfavorable weather conditions or strikes. In addition to this, the multi-day Chinese New Year celebrations are a floating event, whereby the work in the important Chinese container traffic seaports partially ceases. In order to eliminate such irregularities, the seasonally adjusted series is smoothed by the trend-cycle component estimation.

The working day and seasonally adjusted Container Throughput Index shows a close correlation with world trade. The latter is published by the International Monetary Fund and the measured global exports and import details are evaluated in US dollars and the global export or import price indexes are deflated. The volume of world trade is calculated as the mean value of real exports and real imports. The figures are seasonally and work day adjusted and converted into a 2008=100 index in the very beginning (now 2010=100).

Figure 2.6 and Figure 2.7 showed the close correlation between the two series for both the seasonally adjusted as well as their trend-cycle components. The synchronization was distinct, especially during the financial and economic crisis of 2008/09. They developed apart for a short time before and after, but the basic tendency was always similar. At current margins, the Container Throughput Index shows an upturn in global economic activity and this confirms the tendency that was also expressed in the initial world trade estimate. There is also significant correlation with regard to global industrial production. All in all, the Container Throughput Index shows the development of global economic activities quite well.

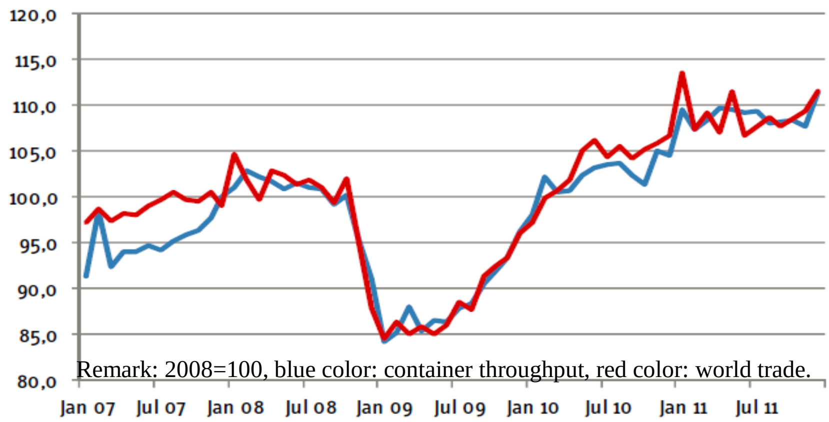


Figure 2.6 World Trade and Container Throughput Index 2007-2011
(Seasonal and Calendar Effects)

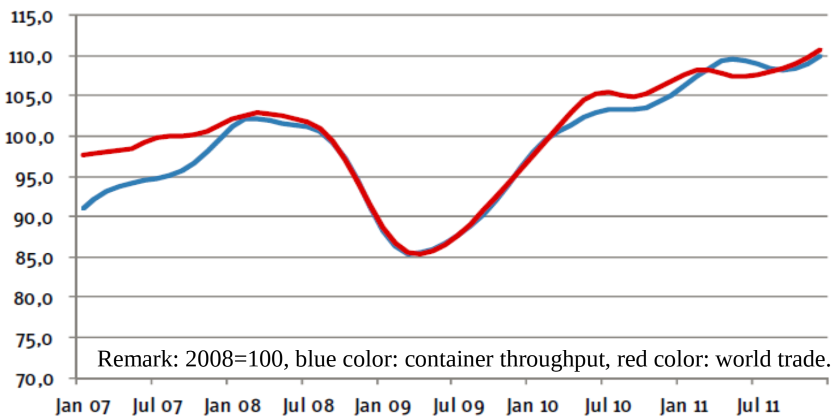


Figure 2.7 World Trade and Container Throughput Index 2007-2011
(Trend-cycle components of the seasonally adjusted values)

2.6 Brief Conclusion

Whatever development of econometrics or escalating container terminal investment analysis, strongly push the research on container throughput. The self-reinforcement process between container terminal scale and low unit operating cost creates container hub while such kind of self-reinforcement was finally conveyed to end users of container terminal to generate new industrial agglomeration and contributes to local economic development. Literature review helped us to clarify two critical issues in this study.

2.6.1 Relation between Container Throughput and National Account

In above literatures, many studies made regression analysis between throughput and macro indicators, especially GDP and international merchandise trade volume. Since transport is generated by trade, it is generally considered that container throughput has obvious cause-effect relationship with consuming, investment and trade just like RWI/ISL Container Throughput Index uses the fact that global economic momentum is the key driving force for all throughput activities while international trade is primarily handled by ships and containers.

Meanwhile, independence between container throughput and national account is also a critical issue which has to be clarified with below analysis.

Firstly, container throughput statistics is a purely physical statistics in TEU term which are generally made by port authority and excludes attribute of commodities' value. However, national account statistics is a purely value statistics in currency term which is made by comprehensive economic administration and excludes product's properties and takes all products as a single product.

Secondly, when one twenty feet container is loaded or discharged between terminal and vessel, one TEU will be added to container throughput statistics. Meanwhile, there are two issues connected with national account statistics. The first one is merchandise trade in value term and another is service charge of container loading or discharging which will be included to GDP statistics. Figure 2.8 illustrated scenario of container loading/discharging operation.

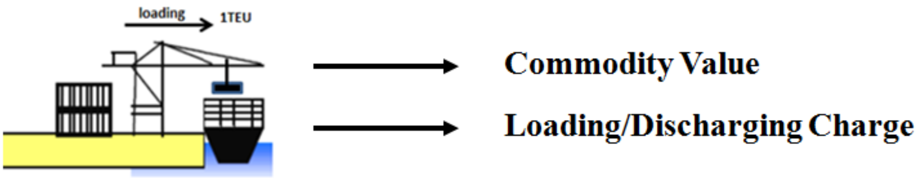


Figure 2.8 Scenario of Container Loading/Discharging Operation

In order to discuss the relationship between merchandise trade in value term and container throughput, it is necessary to refer to below scenarios.

---Scenario 1: value down but container throughput up

There are lots of high-quality paper (For example, copperplate paper) and waste paper exported from Japan to other Asian countries. Waste paper is very cheap because Japanese government and companies want to save garbage disposal cost while copperplate paper is very expensive. Compared with one container copperplate paper, the value of ten containers' waste paper is still cheaper but container throughput has increased a lot.

---Scenario 2: value up but container throughput down

Desktop computer was quite big and heavy twenty years ago but nowadays laptop is much lighter and thinner. If we export 1000 laptops instead of same units of desktop computers, container throughput will be much less than before but the total export value may be higher than before.

---Scenario 3: same cargo but different value in different period

The same tableware's price increased due to inflation but tableware's weight and measurement has no change. Thus, tableware export value will be twenty or thirty percent higher than before but container volume is still same as before.

---Scenario 4: combined cargo in the same container

It is always case that different combined cargo to be stuffed into one container as per consignee's order. It is impossible to connect container throughput with commodities' value since different combination has different value amount.

Above scenarios illustrates that container throughput is not always positively correlated with merchandise trade value and has no absolute relation with commodities' value in the container. Specific commodity's information is essential if we want to connect commodity value with container throughput together. However, when national container throughput is discussed, it is just a pure physical amount which fails to indicate different commodities' properties and takes all the products as a single product. National commodity value is a pure currency amount which does not indicate different commodities' properties. In this sense, container throughput is independent with commodities' value.

Regarding service charge of container loading or discharging, it is generally collected against container movements between vessel and terminal. Basically, the more container throughput, the more service charge will be collected from shipping companies and it will be included into domestic demand in GDP expenditure approach. However, container loading and discharging service charge is only a small part of maritime transport cost. Compared maritime transport, there are also air, land and railway transport modes. Finally, all transport service value-added will be aggregated in Transport and Postal Service industry statistics. But Transport and Postal Service industry has only small share in national account statistics.

For example, Japanese Transport and Postal Service industry just occupied five percent of domestic demand and less than five percent of national GDP in 2011. It is believed that service charge of container loading or discharging will not dominate domestic demand statistics and it can be considered as independent with container throughput.

Thirdly, independent relationship between container throughput and macro indicators is popularly accepted and adopted by a lot of scholars. For example, UNCTAD (RMT (2013)) and Martin Stopford (2009) directly proposed to make analysis between container cargo volume and world macro indicators. Veerachai Gosasang et al. (2011) made linear regression analysis on container throughput by use of national GDP, world GDP and other macro indicators while Liu Bing et al. (2002) made similar linear regression analysis by international trade value, GDP, fixed asset investment and so on.

RWI/ISL Container Throughput Index tried to illustrated trend of international merchandise trade by use of international container throughput and indicated high correlation between international merchandise trade and international container throughput. That means international merchandise trade is generally considered as independent with container throughput.

Overall, container throughput has not absolute relationship with domestic demand or international merchandise trade. It is believed that the reason why so high correlation coefficients were found between container throughput and macro indicators was the development of containerization. With rapid technical development, more and more cargo could be stuffed into container while more special containers were developed to adapt to different cargo, for example, twenty and forty reefer containers for cold supply chain management. Container transport has been connected with our daily life more and more closely.

2.6.2 Relation between Container Throughput and GDP

GDP is the core indicator in modern economic system but it still cannot demonstrate macro economy in all respects while GDP is only a gross quantity and cannot indicate structural economic changes. As per analysis in Part 2.6.1, GDP is independent with container throughput and was a frequently used macro indicator to make regression analysis on container throughput while it is supposed to have positive correlation with container throughput (Let us call such kind of regression model as “GDP Model” hereunder in this study). However, some researches successfully established correlation between GDP and container throughput data series (Syafi’i et al. (2005), Veerachai Gosasang et al. (2011)) while some researches failed in GDP Models (Liu Bing et al. (2002), Jiang Jian et al. (2007)).

Thus, questions were raised as below:

(1) Whether GDP was a suitable independent variable to explain container throughput enough?
(2) What was the correct methodology to make aggregate analysis on container throughput? Were there other macro indicators in national account which can describe container throughput development more accurately?
(3) Was it possible to find a suitable methodology to make structural analysis on container throughput?

This study will discuss above methodological questions in next Part 3. Of course, a lot of researches above did not only use GDP data but also use other macro indicators together, but this study will not discuss other indicators’ influence on container throughput analysis. Since all the explanatory variables are independent with each other, this study will focus on GDP data’s influence on container throughput only and neglect all other macro indicators in this study.

Part 3 Methodology Discussion

"……it is not surprising that shipping executives are preoccupied with the future. But to be realistic, maritime forecasting has a poor reputation, and the sense that forecasts are usually wrong is too widely held in the industry to be taken lightly……"

---Martin Stopford, Maritime Economics 3rd Edition

3.1 Review of Past Methodologies

After further exploring previous literatures, this study concluded several methodological questions as below:

Firstly, most past analyses utilized statistical models to make econometric analysis directly without any business model. GDP Model mentioned before is just such kind of statistical model. However, container throughput analysis is a complex system and business model should be distinguished from statistical model. Besides statistics model indicates regression approach, business model is necessary to explain basic economic theory.

Secondly, though many researches focused on causation analysis, neither data generating process was used nor economic facts behind variables were discussed when regression functions were created. The independent variables were selected arbitrarily and checked by significance test only which would easily lead to nonsense regression just like the story of rainfall and price in Hendry's paper.

Thirdly, transshipment business mainly depends on comparative competitive advantage between hub ports and hardly correlates with local economy background, but no previous study clarified this key issue and gross container throughput including transshipment amount was often used in past researches, that meant the economic facts behind model and data was not consistent.

Fourthly, most researches did not clarify GDP data is nominal or real basis. Only Veerachai Gosasang (2011) clearly clarified usage of real GDP data and America's Container Ports (2011) mentioned real GDP correlated with container throughput in United States. In consideration of the definition, it is easy to understand real macro indicators will much more possibly correlate with container throughput data.

Fifthly, since stable system structure is a sufficient condition for regression analysis, relevant major structures should be evaluated at the same time when regression analysis is made. However, no such kind of evaluation was made in the past researches.

Finally, most past analyses focused on aggregate quantity analysis of container throughput. GDP data was adopted integrally to analyze gross container throughput. There was seldom structural analysis to explore which industries would generate container throughput much more than other industries. It was difficult to find any mechanism explanation between industries and container throughput in past researches.

According to literature review in Part 2, input-output analysis was understood as a structural analysis tool. But when this study searched relevant paper by use of "structure analysis", "structural analysis", "input-output analysis" and "container throughput" in the end of 2017 via internet (www.sciencedirect.com), no such kind of literature could be found. However, a lot of analyses on environment protection by use of input-output analysis were found.

Meanwhile, this study tried to explore the economic facts behind GDP and container throughput by use of GDP expenditure approach. According to literatures reviewed previously, GDP was composed by C, I, G, X and I_m and these five sectors were independent with each other. Below function (3.1) described such kind of relation between variables.

$$\mathrm{CONT} = f(GDP) = f(C, I, G, X, I_m) \tag{3.1}$$

C: personal consuming
I: private investment
G: government expenditure
X: export goods and services in value term
I_m: import goods and services in value term

It was indicated in the past researches that GDP data were supposed to have positive correlation with container throughput and both domestic and international merchandise trade demand stimulated cargo flow, that means:

$$\frac{\partial \mathrm{CONT}}{\partial \mathrm{C}} \geq 0,\ \frac{\partial \mathrm{CONT}}{\partial \mathrm{I}} \geq 0,\ \frac{\partial \mathrm{CONT}}{\partial \mathrm{G}} \geq 0,\ \frac{\partial \mathrm{CONT}}{\partial \mathrm{X}} \geq 0,\ \frac{\partial \mathrm{CONT}}{\partial \mathrm{I_m}} \geq 0 \tag{3.2}$$

However, if we considered equation (2.2), equation (3.3) could be derived as below:

$$\frac{dCONT}{dGDP} = \frac{dCONT}{d(C+I+G+X-I_m)} \tag{3.3}$$

When container throughput was partially differentiated by I_m, equation (3.4) could be derived from equation (3.3) as below:

$$\frac{\partial CONT}{\partial I_m} \leq 0 \tag{3.4}$$

Obviously, equation (3.2) and (3.4) were contradicted in the open macro system and equation (3.4) was not in line with common sense. Compared with closed macro system, the current account was plus in the right of formula (2.2) in open macro system while correspondent international container throughput and transshipment throughput was added to container throughput statistics. However, the current account was the net export while international container throughput was the sum of both export and import container throughput, and transshipment was not correlated with local economic development.

It was clear that the economic facts behind the GDP and container throughput data did not match with each other in open macro economy. In some specific case, GDP was negatively correlated with container throughput but the assumption was always positive correlation. According to Hendry's argument, this meant the economic theory and model was not consistent. Though GDP data had correlation with container throughput data in lots of past researches, it just meant correlation but could not lead to regression to explain container throughput. The regression analysis on container throughput by use of GDP data were questioned as nonsense or false regression.

In fact, GDP and other variables were adopted arbitrarily in many previous studies and only determined by significance test. But according to correct methodology, it is necessary to explore relationship between variables and find their causality at first, secondly make significance test after creating regression function. Without qualitative analysis on the causality between variables in advance, the former methodology will generate nonsense regression easily.

3.2 Approach New Methodology

Though GDP is still correlated with container throughput in many researches, it does not imply causation. The qualitative analysis in Part 3.1 denied its causal relationship with container throughput. However, container throughput is so important for government planning, private investment and even environment protection that it is necessary to develop a new methodology for both container aggregate and structural analysis.

3.2.1 Approach Container Throughput Generation Mechanism

In consideration of Hendry's trinity of economic theory, observed data and econometric model, container throughput generation mechanism was approached to explore business model between container transport and macro indicators.

Though theoretically there are many container throughput generation mechanisms, practically function (2.15) is the best description of container throughput generation mechanism which explicitly explains three segments by use of trade nature and has good data accessibility at the same time.

$$CONT = DC + IC + TC \tag{2.15}$$

DC: domestic container throughput
IC: international container throughput
TC: international transshipment container throughput

Many countries release container throughput data in terms of domestic, international and transshipment trade and this is the only accessible data source of container throughput segment for researchers. Therefore, we made use of this generation mechanism in this study and did not spend time on other mechanism which could not secure the data accessibility.

Since domestic container transport meets demand of domestic merchandise trade when international container transport meets the same of international merchandise trade, it is possible to find macro indicators within SNA to correspond to domestic and international merchandise trade.

One more general practice recognized is domestic and international container shipments are generally handled by separate terminals in most countries because of customs-supervised policy. Basically, international and international transshipment container traffic is bonded business and can only be handled in a specifically closed bonded area while domestic container traffic can be handled in open area. Meanwhile, most domestic container transport vessel's size is quite smaller than the same of oceangoing vessel. Thus, domestic container terminal's particulars, for example, length, draft and gantry are so different from international container terminal's particulars that domestic container terminals can hardly accommodate ocean-going vessels unless additional huge reform is financed.

This general practice highlights that container throughput segments are independent and should be analyzed individually. Though government officials always conduct gross container throughput analysis when they make planning for national or regional transport supply demand analysis, they just consider comprehensive utilization of coastal line and physical distribution access to hinterland on the macro level. For specific terminal planning or investment case, it is still necessary to distinguish domestic and international business at first.

Table 3.1 can help us to roughly understand historic process of global economic development with container transport together.

Table 3.1 Historic Development of Global Economy and Container Transport

Period	Closed Macro Economy	Open Macro Economy	
	Stage I	Stage II	Stage III
Scenario	No int'l trade	Int'l merchandise trade without transshipment	Int'l merchandise trade With transshipment
GDP Formula	GDP=C+I+G	GDP=C+I+G+X-Im	GDP=C+I+G+X-Im
Business Model	CONT=DC	CONT=GC=DC+IC	CONT=DC+IC+TC or CONT-TC=DC+IC=GC
Statistic Model	$DC=f_1(x)$	$DC= f_1(x)$ $IC=f_2(y)$	$DC= f_1(x)$ $IC=f_2(y)$

Remark：1. GC denotes gateway container throughput and the sum of DC and IC (GC=DC+IC).
2. x and y denote macro indicators which can explain DC and IC.

It is easy to understand scenario of stage I and its business model. In Stage II, since DC is independent with IC and has been defined in Stage 1, IC can be explained by international merchandise trade. In Stage III, transshipment business happens but TC has to be deducted from gross container throughput before regression analysis is made since TC is hardly linked with local economy. That means only gateway container throughput is generally connected with macro economy and gross container throughput can only be correlated with macro economy in some specific case.

By being decomposed into three simple systems, DC, IC and TC in formula (2.16), the complex system of container throughput can be analyzed individually in every simple system by use of regression analysis. After that, the output of three simple systems can be integrated to get final output of container throughput

The method of integration after decomposition is completely different from GDP Model's combination forecasting and provides possible solution to ensure the consistency of model and theory.

3.2.2 Approach Consistent Variables

After achieving consistency between theory and model, it is necessary to look for consistent data with model. However, it is not easy to achieve absolute coherency between model and data due to limited data source. Thus, this study set up three principles as below in order to look for new variables for container throughput regression analysis:

(1) New independent variables have causal but independent relationship with container throughput or its segments;
(2) New independent variables have high quality historic data;
(3) Historic data source is easily accessible.

Since not every government releases macro statistics data by maritime container transport mode, this study can only adopt the macro indicators which are most consistent with economic facts behind container throughput. Of course, such kind of situation does not only happen in container throughput research but also in most economic research.

In consideration of data accessibility and data statistic standard, our priority is to identify indicators which match with container throughput generation mechanism as much as possible in SNA to enhance the consistence between model and data.

3.2.3 Approach Data Processing

Once independent variables are selected, it is necessary to process the data accordingly. Since trade data is composed of two factors: cargo or service volume and their unit price, unit price fluctuation will have influence on trade data series while in fact no additional container throughput will be generated. Same volume of commodity will not make any more contribution to container throughput even if the price is double increased in the next year with inflation because the weight and measurement has no change.

It is obvious that economic data in real term which minimizes unit price volatility is much better to be used in container throughput analysis. Therefore, all the macro data used in this study should be processed by deflator in the first place. This process further enhanced the consistence of economic facts behind macro indicators and container transport.

In aggregate empirical analysis, macro indicator data series in real term was used while producer's price was being adopted in structural analysis to match the physical production as much as possible.

3.3 Aggregate Analysis Methodology

Besides above common points in new methodology, this study developed specific aggregate and structural analysis methodologies separately.

3.3.1 Development of Business Model

In fact, equation (2.15) is the only one choice due to its data accessibility since no other container throughput data are released by countries or port authorities. In consideration of all the macro indicators in SNA and container throughput generation mechanism, domestic demand (C+I+G) was chosen to respond to domestic container throughput (DC) and international merchandise trade volume $(X' + Im')$ was chosen to respond to international container throughput (IC) (See function (3.5) and (3.6)). Domestic demand and international merchandise trade were believed as most easily found variables in SNA while function (3.5) and (3.6) described the economic facts behind macro indicators and container throughput more accurately than previous study. The independence between above variables has been cleared in Part 2.6.1.

$$DC = f_1(C + I + G) \quad (3.5)$$
$$IC = f_2(X' + I_m') \quad (3.6)$$

X': export merchandise volume.
I_m': import merchandise volume.

Function (3.7) was developed from formula (2.16), function (3.5) and function (3.6).

$$CONT = DC + IC + TC = f_1(C + I + G) + f_2(X' + I_m') + TC \quad (3.7)$$

Function (3.5), (3.6) and (3.7) evidently indicated the integrated approach after decomposing complex system. Since all the variables were adopted from GDP expenditure approach, this frame was called as "expenditure frame" hereafter.

Here was second economic fact which has to confirm. As per previous literatures, transshipment container throughput basically relies on comparative competitive advantage between hub ports rather than correlation with local economic development. In light of this, function (3.7) was changed into below function (3.8):

$$CONT - TC = GC = DC + IC = f_1(C + I + G) + f_2(X' + I_m') \quad (3.8)$$

(CONT-TC) represented gateway container throughput (GC) demand firstly stated in Table 3.1. f_1 and f_2 could be developed by function (3.5) and (3.6) in simple system.

Additionally, a new variable $(C + I + G + X' + I_m')$ was created to indicate container throughput and supposed function (3.9) as below:

$$CONT - TC = GC = DC + IC = f(C + I + G + X' + I_m') \quad (3.9)$$

$(C + I + G + X' + I_m')$ was defined as "gross demand" in expenditure frame. Though gross demand is different from GDP, two parts (domestic demand and international merchandise trade in value term) were adopted from national account so that gross demand was independent with container throughput and could be used for further regression analysis as per analysis in Part 2.6.1. Function (3.9) looked like GDP Model, but the economic fact behind it was completely different with GDP and described more common facts with container throughput.

For production frame, same methodology was adopted to get below function (3.10):

$$\mathrm{CONT} - \mathrm{TC} = f_3(\mathrm{PRI} + \mathrm{SEC} - X' + \mathrm{Im}') + f_4(X' + I_m{}') \quad (3.10)$$

In order to control the length of this article, this study only focused on discussion of expenditure approach and product approach analysis had almost same outcome as expenditure approach.

3.3.2 Transshipment Identification

For container hub ports, transshipment volume is quite big so that the gross demand can only be correlated with gateway container throughput. But in other ports, transshipment segment can be neglected if the volume is not influential enough and gross demand could be correlated with gross container throughput directly.

In Japan, both domestic and international transshipment volume was not big enough so that its influence was neglected. In Korea, the international transshipment volume occupied quite big share of its total throughput. According to officially released data, Korea's international transshipment volume reached 35.6% of total container throughput in year of 2014 so that transshipment volume shall be deducted from gross container throughput before relevant correlation analysis was made.

In China, the situation became a little bit complicated. According to Report on China's Shipping Development (RCSD, (1998-2014)), international transshipment volume was still quite small and never officially announced but the cargo volume of domestic feeder for international trade was quite big. It is well known that China has more than 5000 kilometers coastline. Every shipping company tries to set up its own coastal feeder networks to attract more cargos. In the meantime, the cargo from upstream of Yangtze River has to be transshipped in Shanghai because vessel's safety standard for river navigation is completely different from sea navigation while small container vessel in Yangtze River cannot compete with large-sized container vessel due to its unit cost disadvantage.

The data annually released by RCSD showed this sector occupied more than 10% of China's container throughput in 2013 and 2014. As this part of container throughput did not make additional contribution to international trade statistics but increase the container throughput remarkably, it should be treated same as international transshipment volume and removed from the total throughput accordingly.

Table 3.2 Domestic Feeder for International Trade Share in China

Year	Domestic Feeder for Int'l Trade (10,000 TEU)	Container Throughput (10,000 TEU)	Percent
1998	145	1,312	11.05%
1999	160	1,806	8.86%
2000	167	2,348	7.11%
2001	131	2,748	4.77%
2002	187	3,721	5.03%
2003	303	4,867	6.23%
2004	437	6,160	7.09%
2005	524	7,564	6.93%
2006	671	9,361	7.17%
2007	940	11,444	8.21%
2008	1,131	12,831	8.81%
2009	1,051	12,240	8.59%
2010	1,198	14,613	8.20%
2011	1,473	16,367	9.00%
2012	1,772	17,747	9.98%
2013	1,941	19,021	10.20%
2014	2,030	20,244	10.03%

Data source: from Report on China's Shipping Development 1998-2014, Ministry of Transport of the People's Republic of China

Finally, while transshipment volume being removed from gross container throughput, the economic contribution to local economy brought by transshipment business has to be equally considered. If necessary, the same revenue brought by transshipment business should be deducted from local macroeconomic statistics. Relevant transshipment stevedoring cost of Hong Kong and Korea was collected to make a simulation.

In Hong Kong, the stevedoring tariff for 20 feet container was about HK$650 including one loading and one discharging movement together and it was HK$1014 for 40 feet container with the same condition in 2013. The ratio of 20 feet container to 40 feet container was supposed to be 1:2 and 13.74 million TEUs transshipment container throughput in 2013 was used to make the simulation, it was calculated that transshipment business brought 7 billion HK dollars to local GDP. Of course, there was still some horizontal movement between different terminals, but compared with Hong Kong's GDP of 2000 billion HK dollars this contribution was only quite small 0.35% and could be ignored. The same situation happened in Korea since about 10 million twenty-feet equivalent units transshipment business only brought about 0.2% contribution to local nominal gross domestic product in 2014.

The result was transshipment business did not make remarkable contribution to local economy even in the world biggest hub and could be neglected though it brought some service revenue to local economy.

3.3.3 Structure Evaluation

Generally, government agency only releases macro statistics data by maritime transport mode. Sometimes there is no way but to use such kind of statistical data as substitutes to make container throughput regression analysis. Within this study, only Japanese government announced international merchandise data from 1998 to 2008 by container transport mode and no other countries releases same data any more. Thus, it is necessary to explore how much container transport components are reflected in the macro data released since stable system structure is the sufficient condition for sound regression analysis.

Figure 3.1 illustrates the image of container transport supply and demand factors. Circle 1 stands for container transport demand/supply in value wise when Circle 2 and Circle 3 stand for transport supply/demand in maritime transport wise and gross transport supply/demand. Theoretically, transport demand is equal to transport supply in every segment and totally. The extreme case is Circle 1, 2 and 3 completely overlapped, that means all the trade is carried by container transport.

Obviously, the bigger Circle 1, the more correlation and causality will have between transport demand and container throughput. However, the size of Circle 1 changed from left picture to right picture tells us more cargos are carried by container transport in the right picture. On the one hand, it means transport structure has been changed. On the other hand, it implies demand structure has been changed, or even implies industry structure has been comparatively changed as container transport is closely connected with physical industry while most containerized cargo is intermediate and finished goods. Under the globalization background, container transport and container throughput is just a mirror of industry and its structure. High container transport share in transport structure implies country's power of process and manufacturing industries.

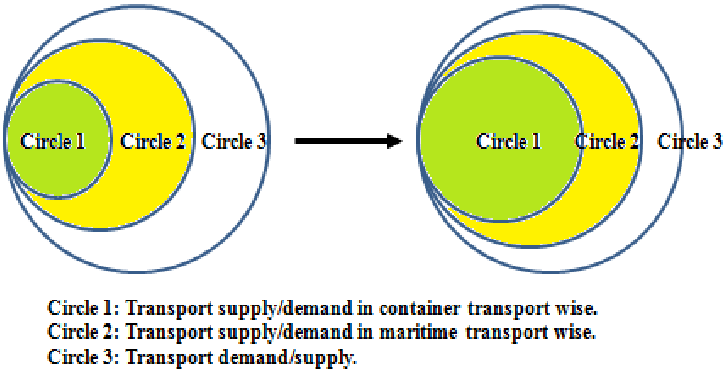


Figure 3.1 Diagram of Structure Evaluation

Refer to above RMT (2013), container trade flows prediction should take consideration of factors include the rate of off-shoring of manufacturing, the extent of containerization of bulk cargoes, the goods-versus-services composition and the manufactured-versus -commodities share of countries. In view of this comments, this study proposed industry, trade and transport structure as most important evaluation contents for container throughput analysis.

So far this was still a qualitative analysis. The current study only recognized economic background would have influence on container throughput analysis but how much structure volatility will lead to failure of regression analysis was still not grasped. However, such a structure analysis at least provides us with a broader background to look at the quantitative outputs of regression analysis.

3.3.4 Integrated Analysis

Pure quantitative analysis cannot answer all questions. The integrated analysis means combined quantitative and qualitative analysis rather than the integration of three subsystem's regression analysis outputs. So far, the causality identification and selection of independent variables still depends on qualitative analysis when economic structure evaluation is another qualitative analysis, too. Quantitative analysis focuses only on data process and usage of statistical model. Quantitative and qualitative analysis have the cross-checking function and only the combination of these two analyses can lead to sound causality and regression as we expect.

3.4 Structural Analysis Methodology

Though aggregate analysis between macro economy and container throughput is very important, we still do not know how much container throughput is generated by every department in macro economy. Just like Lechao Liu et al. (2011) pointed out that though many researches focused on container throughput forecast, there were not many papers focused on which factor had the strongest influence to container throughputs of Korea and China and what the cause was.

Meanwhile, input-output analysis was used in many other fields especially in carbon emission research. X.F. Wu et al. (2017) adopted cross-scale input-output analysis to track the energy use from the source of exploitation to the sink of final use in China. Some tertiary industries were regarded as the zero-energy sectors in the traditional direct accounting, but were found with a considerable amount of energy use in their supply chains, as indicated by their embodied energy intensities.

B. Zhang et al. (2016) investigated the temporal and spatial changes of embodied energy transfers via China's domestic trade over 2002–2007 based on the multi-regional input–output models. The paper proposed to achieve more appropriate policy designs for energy saving and emission reduction by considering China's regional diversity and complexity.

Matteo V. Rocco et al. (2016) formalized and applied international trade treatment methods in Input-Output analysis to a case study based on the World Input-Output Database (WIOD).

Such kind of researches reminded us to think about container throughput studies. For example, tertiary industry has no relationship with container throughput intuitively. Is it true or just an illusion? Structural analysis is expected to catch endogenous connection between container throughput and various industries in macro economy.

3.4.1 Development of Business Model

From the literature investigation, input-output analysis was found to be a potential methodology for us to approach structural analysis. Input-output transactions table does not only provide demand in industry wise but also inter-industry flow which really triggers container transport demand while GDP data only reflect gross value added of macro economy.

Since transport was driven by merchandise trade, container throughput was supposed to be a function of gross output of all industries as below:

$$CONT = L_{cont} \cdot X = \begin{bmatrix} l_1 & l_2 & \cdots & l_n \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \tag{3.11}$$

L_{cont}: matrix of conversion coefficient between gross output and container throughput for every industry.

X: matrix of gross output.

l_i: conversion coefficient from gross output to container throughput for industrial Department i.

x_i: gross output of industrial Department i.

In function (3.11), data series of gross output can be approached from national input-output table which is released regularly by many countries. For example, there were two types input-output table released by Japanese government every five years. The simplest type included 13 industries(11) (See Appendix 7) and the second type included 37 industries(12).

Meanwhile, quantitative relationship between container throughput and final demand of every industry was developed as below function (3.12) by equation (2.10):

$$CONT = L_{cont} \cdot X = [l_1 \quad l_2 \quad \cdots \quad l_n] \cdot (I-A)^{-1} \cdot \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \tag{3.12}$$

Furthermore, same container throughput generation mechanism (2.15) was used to divide gross throughput into three simple systems and below function (3.13) and (3.14) were derived.

$$DC = L_{dc} \cdot X \tag{3.13}$$
$$IC = L_{ic} \cdot X \tag{3.14}$$

L_{dc}: conversion coefficient matrix between gross output and domestic container throughput.
L_{ic}: conversion coefficient matrix between gross output and international container throughput.

Different conversion coefficient matrices indicate different mechanism between domestic and international container throughput.

3.4.2 Conversion Coefficient

For Agriculture, Mining, Manufacturing or other industries, its output are tangible or physical goods so that it is necessary to analyze conversion coefficients one by one. In different country, there are different conversion coefficients even for same industry since different countries have different industry structure. For example, Vietnam is keeping very fast development of light industry while China produces both heavy industry and light industry goods at the same time. Obviously, the conversion coefficient of Manufacturing industry in Vietnam and China should be different because light industry and heavy industry goods in the same value will often generate different container transport demand.

Meanwhile, it is easy to understand that service industries will not generate container throughput directly because their output is intangible goods which will not carried by maritime container. Thus, conversion coefficients of service industries, just like Commerce, Hotel & Restaurant, Information & Communications, Financial & Insurance and Real Estate in any countries, can be assumed to be zero.

Anyway, above equations (3.13) and equation (3.14) indicated that we could make quantitative analysis between container throughput segments and gross output if we could find conversion coefficient matrix. For example, conversion coefficient was in TEU/Yen term in Japan since gross output is in local currency Yen and container throughput was in TEU. If we could find enough statistics data with both cargo volume and value, it was possible for us to calculate the conversion coefficient.

As per literature review in Part 2, Ma (2006) was found to deal with the same conversion between value and TEU. Ma took three steps to convert value term into TEU term. Firstly, he looked for trade data with both volume and value and get unit price in JPY/FT; secondly, he took average 19FT/TEU data from professional handbook; finally he calculated JPY/TEU result by multiplying previous two data. FT means freight ton which was bigger amount between weight and cubic measurement.

Same methodology was adopted to take empirical analysis in this study later. In consideration of data collection, international trade has better statistic system than domestic trade. It is easy to find trade data with both weight and value term for international merchandise trade by use of website of the Ministry of Finance, Japan. In fact, Customs House had very strict statistic system to provide full set of export and import shipment data.

Since it was difficult to find relevant domestic trade data with both weight and value term so that this study only made empirical input-output analysis on the relationship between international trade and international container throughput in Japan. It was believed the methodology was same and once data was available it was quite possible to find the inter-relationship between gross output and domestic container throughput.

3.4.3 Structure Evaluation

Since GDP statistics only keeps stable structure within one reporting period, direct input coefficient and Leontief inverse matrix will change regularly. This structural analysis methodology is only workable for short-term container throughput analysis. Compared with aggregate analysis, this study did not propose structure evaluation in structural analysis. But it does not mean stable system structure is not important to structural analysis. In fact, stable system structure has been included in structural analysis within every report period.

This is first time for input-output analysis to be used to explore inter -relationship between macro economy and gateway container throughput. In fact, the aggregate analysis and structural analysis are interrelated. The aggregate analysis focuses on the gross index speed and dynamic process of economic development. Structural analysis focuses on the relationship between the components of the whole economy within one reporting period and relatively static state of the economic phenomenon. Compared with aggregate analysis, structural analysis has deepening and supplement function while it should be subordinated to the target of aggregate analysis. In order to fully grasp the trend of economic development, it is necessary to combine aggregate analysis with structural analysis together.

3.5 Brief Conclusion

Undoubtedly, container throughput is so important that even world container port ranking is made by itself because it demonstrates container terminal's income and scale. After questioning GDP Model, our ultimate object was to develop a new methodology both for future's aggregate and structural analysis.

For aggregate analysis, new methodology could be concluded into Figure 3.2 including quantitative and qualitative analysis respectively.

Anyway, what this study focus was not only correlation but also sound regression between macro indicators and container throughput. The qualitative analysis will enable us to prevent nonsense regression and find the exact factors which will have substantial influence on container throughput. It is expected that both quantitative and qualitative analysis will reinforce each other and help us to understand causality much easier. The comparison between past GDP-based methodology and proposed methodology was concluded in below Table 3.3.

Obviously, there are various container throughput generation mechanisms existing with different macro indicators which can explain container throughput segments when every group of explanatory variables decides different contents of structure evaluation. This study would like to define one kind of mechanism with accessible variables and structure evaluation as a "frame" just like the content within the dot line of Figure 3.2 before statistical model is used. It is clear that there are several such kind of frame existing and every frame is independent to statistical models and qualitative methods.

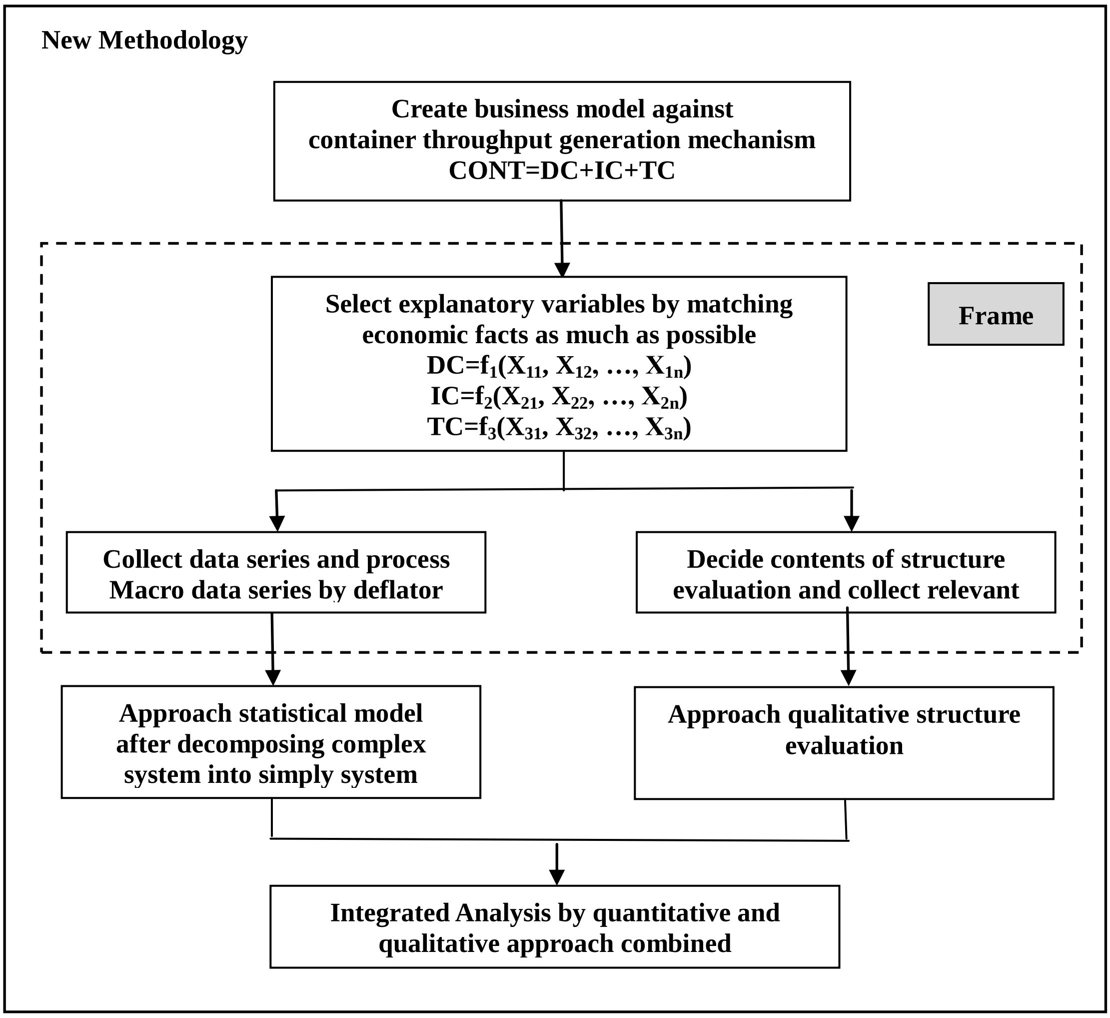


Figure 3.2 Outline of Methodology of Container Throughput Regression Analysis

Table 3.3 Comparison between GDP-based Methodology and Proposed Methodology

Item	GDP-based Methodology	Proposed Methodology
Kind of system	Simple system	Complex system
Business model	None	CONT=DC+IC+TC
Independent variable	GDP	DC: $X_{11}, X_{12}, \ldots, X_{1n}$ IC: $X_{21}, X_{22}, \ldots, X_{2n}$ TC: $X_{31}, X_{32}, \ldots, X_{3n}$
Causality with container throughput generation mechanism	Partially conflict	Yes
Statistical model	CONT=f(GDP)	$DC=f_1(X_{11}, X_{12}, \ldots, X_{1n})$ $IC=f_2(X_{21}, X_{22}, \ldots, X_{2n})$ $TC=f_3(X_{31}, X_{32}, \ldots, X_{3n})$
Deflator processing	No	Yes
Transshipment identification	No	Yes
Consistent theory and model	No	Yes
Consistent model and data	Partially	Partially
Structure evaluation	No	Yes
Integrated analysis	No	Yes

For aggregate analysis, this study tried to realize the consistence between theory and model while matching the economic facts behind model and data as much as possible. Considering empirical analysis in Part 4, there were three assumptions which had to be checked: firstly, real macro data had higher correlation with container throughput data than nominal macro data; secondly, gross demand in frame had high correlation with container throughput; thirdly, the data with more container trade facts had more correlation with container throughput.

For structural analysis, this study made use of input-output analysis to bridge the connection between industries' final demand and container throughput. Especially, it is possible to visualize the connection between non-physical industries and container throughput and find a methodology to explain even service industries could generate container throughput same as physical industries. That would tell us the story why developed countries did not process so many physical products but their container throughput per head was still higher than a lot of developing countries.

Relevant empirical analysis was made in later Part 4 and Part 5 with Japan, China, Korea and Hong Kong's data. In fact, these three countries and Hong Kong have made and are making their special contribution to world maritime container transport.

Japan is the third biggest economic entity in the world and the only developed country which experienced twenty years stagflation, especially the deflation after 2000. Before Hansin Earthquake, Kobe was once the hub in Northeast Asia. Meanwhile, Japanese government released high quality statistics data series which enabled us to make both aggregate and structural analysis.

China is the biggest developing country and the second biggest economic entity, her rapid economic development after joining WTO has been contributing much to the global container throughput soaring after 2000. As always called "world factory", China has overtaken United States as the country with biggest container throughput since 2001 and become the top world exporter since 2009 with 10 percent of the value of traded merchandise.

Korea is an emerging developed country who has successfully set up the container hub port in Busan and attracts huge transshipment container cargo from both Japan and China.

Hong Kong is the Special Administration Region (SAR) in China now and was once the biggest container hub one decade ago and attracted huge amount transshipment cargo mainly from South China. Due to its geographical advantage and service trade development, Hong Kong is also one of global trade and finance centers. In the meantime, Hong Kong has its independent customs system with perfect statistic system.

These three states and one SAR with different macro economy characteristics and different economic structures provided us a more comprehensive vision of macro economy and container throughput.

Part 4 Empirical Aggregate Analysis

"……For far long economists have sought to define themselves in term of their supposedly scientific methods. In fact, those methods rely on an immoderate use of mathematical models, which are frequently no more than an excuse for occupying the terrain and masking the vacuity of the content. Too much energy has been and still is being wasted on pure theoretical speculation without a clear specification of the economic facts one is trying to explain or the social and political problems one is trying to resolve….."

---Thomas Piketty, The Capital in the Twenty First Century

In last chapter, this study tried to re-organize aggregate analysis methodology after GDP was questioned to be a suitable independent variable for container throughput analysis. In line with this methodology, empirical aggregate analysis was made in this part after transshipment volume was removed and all macro data series were processed by deflator.

4.1 Data Source and Process

All the data used in this research were from Japan, China, Korea and Hong Kong government or other major international organization as shown in Table 4.1. The principle was to adopt data from international organization and government office with national currency.

In expenditure frame, most macro indicators were found from the website of International Monetary Fund (IMF) only with several exceptions. For Japan, the international merchandise trade amount by maritime container trade was fortunately found on the website of Ministry of Finance. For China, the current account data from 1990-1996 was taken from National Bureau of Statistics of the PRC (NBS) as IMF failed to indicate the same data. Hong Kong government provided excellent systematic database for macro economy which was in line with IMF perfectly so that all the data of Hong Kong in this research was picked up from Hong Kong Annual Digest of Statistics (HK-ADS 1992-2014) .

Regarding container throughput, Japan's data was found in government official website of Ministry of Land, Infrastructure, Transport and Tourism (MLIT). China's data was taken from China Ports & Harbors Association (CPHA) and Report on China's Shipping Development (RCSD) while Korea's data was picked up from Shipping and Port – Integrated Data Center (SP-IDC) which was supported by Ministry of Oceans and Fisheries (MOF) in Korea. It was quite helpful to us that transshipment cargo volume was found on the website of SP-IDC (http://www.spidc.go.kr). Hong Kong Shipping Statistics (1992-2014) not only provided maritime container throughput data series but also published regular analysis report which gave us much reference.

Table 4.1 Macro Economy and Container Throughput Data Sources

Data	Japan	China	Korea	Hong Kong SAR
GDP	IMF	IMF	IMF	HK-ADS (1992-2014)
Current Account	(Same as above)	(Same as above)	(Same as above)	(Same as above)
International Merchandise Trade	(Same as above)	(Same as above)	(Same as above)	HK-ADS (1992-2014)
International Merchandise Trade by container transport	Ministry of Finance（2000-2008）	-	-	-
Industries' Value Added	Ministry of Finance（1994-2014）	NBS (1991-2014)	World Bank (1990-2014)	HK-ADS (1992-2014)
Deflator	IMF	IMF	IMF	IMF
Exchange Rate	IMF	IMF	IMF	IMF
Container Throughput	MLIT of Japan (2000-2014)	CPHA (1990-1996) RCSD (1997-2014)	SP-IDC (1990-2014)	HK Shipping Statistics (1992-2014)
Domestic Container Throughput	MLIT of Japan (2000-2014)	RCSD (1997-2014)	(Same as above)	-
International Container Throughput	MLIT of Japan (2000-2014)	(Same as above)	(Same as above)	HK Shipping Statistics (1992-2014)
International Transshipment Throughput	-	-	(Same as above)	(Same as above)
Container Throughput of domestic feeder for international trade	-	RCSD (1997-2014)	-	-

The historic data highlighted container transport had close connection with macro economy, for example, international merchandise trade value by containers in Japan occupied 40% of total international merchandise trade and 10% of GDP.

As stated above, real macro data which removed unit price fluctuation was adopted in this methodology research. Deflator was used to process the macroeconomic data and its components to get the "real" basic data with constant price before regression analysis was made. China is a typical case that average unit price has increased more than three times from 1990 to 2014, so the data series of nominal and real GDP data had evident influence on analysis outcome.

In the meantime, the national currency was used in this study. As per IMF or other international organization released data, the economic indicators just like GDP are always shown in national currency and US dollar at the same time. Though exchange rate basically reflects country's fundamental economic situation, sometimes it is still influenced by manipulation or speculation. The national currency will minimize such kind of negative influence to data series.

4.2 Structure Evaluation

As per analysis in Part 3.3.3, it was not always case that the economic facts behind data could completely match. The question was whether these most consistent data could reflect features of maritime container transport enough. In consideration of the variables used in the new frames, namely domestic demand and international merchandise trade, it is necessary to evaluate industry, trade and transport structure in broad sense further as per Fig 3.1.

In fact, industry structure decides trade demand and its structure. Furthermore, trade demand and structure combined with its geographic feature decides transport demand and its structure. Industry, trade and transport structures work together to provide a macroeconomic environment for container throughput analysis. According to the discussion in Part 3, domestic industry, international merchandise trade and transport structure was reviewed for Japan, China, Korea and Hong Kong SAR one by one.

4.2.1 Domestic Industry Structure

Below statistics material was picked up from World Bank website as below tables.

Table 4.2 China Industry Value Added Share of GDP (in percent)

Year	Agriculture	Industry	Manufacturing	Services
1990	27	41	32	32
2000	15	45	32	40
2006	11	47	33	42
2007	10	47	33	43
2008	10	47	32	43
2009	10	46	32	44
2010	10	46	32	44
2011	10	46	32	44
2012	10	45	31	46
2013	9	44	30	47
2014	9	43	..	48

Data source: from World Development Indicators, World Databank, World Bank

Table 4.3 Japan Industry Value Added Share of GDP (in percent)

Year	Agriculture	Industry	Manufacturing	Services
1990	2	38	26	60
2000	2	31	21	67
2006	1	28	20	71
2007	1	28	20	71
2008	1	28	20	71
2009	1	26	18	73
2010	1	28	20	71
2011	1	26	19	73
2012	1	26	19	73
2013	1	26	19	73
2014	1	27	20	72

Data source: from World Development Indicators, World Databank, World Bank

Table 4.4 Korea Industry Value Added Share of GDP (in percent)

Year	Agriculture	Industry	Manufacturing	Services
1990	8	38	25	54
2000	4	38	29	58
2006	3	37	28	60
2007	3	37	28	60
2008	3	36	29	61
2009	3	37	29	61
2010	2	38	31	59
2011	3	38	31	59
2012	2	38	31	59
2013	2	38	31	59
2014	2	38	30	59

Data source: from World Development Indicators, World Databank, World Bank

Table 4.5 Hong Kong Industry Value Added Share of GDP (in percent)

Year	Agriculture	Industry	Manufacturing	Services
1990	..	..	..	..
2000	0	12	5	88
2006	0	8	3	92
2007	0	7	2	93
2008	0	7	2	93
2009	0	7	2	93
2010	0	7	2	93
2011	0	7	2	93
2012	0	7	2	93
2013	0	7	1	93
2014	0	7	1	93

Data source: from World Development Indicators, World Databank, World Bank

Compared with China, Japan and Korea, Hong Kong service industry almost completely dominated regional economic development which indicated the possibility that domestic demand had hardly connection with physical container transport in last two decades. Of course, further correlation coefficient calculation gave us more evidence.

4.2.2 International Merchandise Trade Structure

Similar to off-shoring manufacturing mentioned in Review of Maritime Transport (2013), re-export trade will be very crucial to international container throughput analysis since it interferes with local export economic feature. Meanwhile, there is no government to announce container throughput of re-export trade separately so that the correlation analysis between international container throughput and international merchandise trade volume will be interfered respectively.

Re-export trade always happens in the container hub. Most container hubs all over the world are trade centers simultaneously due to it traffic advantage to international trade. Korea and Hong Kong officially release re-export trade volume in terms of value but both China and Japan do not release such kind of statistic data.

In Table 4.6 and 4.7, re-export in Hong Kong was quite big enough to have potential influence on correlation analysis between international container throughput and international merchandise trade in value term. Korea's re-export share was very small and could be neglected accordingly.

Table 4.6 Hong Kong Re-export Trade Share in International Merchandise Trade

Year	Re-export (in million HKD)	International merchandise trade (in million HKD)	Share (in percent)
1992	1,262,836	1,880,247	67%
1993	1,495,797	2,118,848	71%
1994	1,737,540	2,420,722	72%
1995	2,041,382	2,835,248	72%
1996	2,166,380	2,933,500	74%
1997	2,267,550	3,071,039	74%
1998	2,101,621	2,776,741	76%
1999	2,117,585	2,741,718	77%
2000	2,489,791	3,230,651	77%
2001	2,386,785	3,049,181	78%
2002	2,586,128	3,179,935	81%
2003	2,951,384	3,548,206	83%
2004	3,458,752	4,130,237	84%
2005	3,858,311	4,579,642	84%
2006	4,257,495	5,060,831	84%
2007	4,714,770	5,555,525	85%
2008	4,988,252	5,849,439	85%
2009	4,416,357	5,161,445	86%
2010	5,451,631	6,395,859	85%
2011	6,010,110	7,101,850	85%
2012	6,231,068	7,346,509	85%
2013	6,461,500	7,620,403	85%

Data source: from Hong Kong Annual Digest of Statistics, 1992-2013

Table 4.7 Korea Re-export Trade Share in International Merchandise Trade

Year	Re-export (in thousand USD)	Export merchandise trade (in thousand USD)	Share (in Percent)
1992	216,729	7,6631515	0.3
1993	266,511	82,235,866	0.3
1994	643,816	96,013,237	0.7
1995	2,620,607	125,057,988	2.1
1996	4,769,366	129,715,137	3.7
1997	3,471,172	136,164,204	2.5
1998	1,672,891	132,313,143	1.3
1999	1,135,741	143,685,459	0.8
2000	884,208	172,267,510	0.5
2001	685,176	150,439,144	0.5
2002	675,587	162,470,528	0.4
2003	770,136	193,817,443	0.4
2004	934,386	253,844,672	0.4
2005	1,340,047	284,418,743	0.5
2006	1,421,581	325,464,848	0.4
2007	1,664,939	371,489,086	0.4
2008	1,997,722	380,439,327	0.5
2009	1,424,217	322,865,368	0.4
2010	2,005,087	415,171,418	0.4
2011	2,597,847	501,398,645	0.5
2012	2,377,234	498,234,490	0.4
2013	2,228,540	510,775,231	0.4
2014	2,425,664	519,824,945	0.4

Data source: from Korea International Trade Association

4.2.3 Transport Structure

With the development of science and technologies, commodities' unit value and measurement as well as transport technology are always changing, even same kind of cargo will adopt different transport mode over time so that transport structure is always fluctuating. Since this study adopted gross demand data by all kinds of transport modes same as most studies made before, transport structure has to be checked in advance.

In 2013, the value of Hong Kong's international merchandise trade by land transport accounted for 38.4 percent of Hong Kong's total value of trade in goods. Another 37.4 percent was transported by air transport, 20.2 percent by ocean transport and 2.9 percent by river transport. The remaining 1.1 percent was mainly postal parcels and accompanied goods of passengers travelling by various means of transport.

In terms of value, air and land transport have replaced ocean transport as the most important modes of transport in Hong Kong's total trade in goods since 2005 (See Table 4.8).

Table 4.8 Values of Hong Kong's International Merchandise Trade by Mode of Transport

Mode of Transport	1993		2013	
	Billion HKD	Share (in percent)	Billion HKD	Share (in percent)
Air	390.1	18.4	2853.0	37.4
Land	556.6	26.3	2922.5	38.4
Ocean	1074.1	50.7	1539.5	20.2
River	91.7	4.3	221.2	2.9
Others	6.4	0.3	84.1	1.1
Total	2118.9	100.0	7620.4	100.0

Data source: from Analysis of Hong Kong's External Merchandise Trade by Mode of Transport (2014), Census and Statistics Department of Hong Kong SAR

In fact, this structure made us most surprised in the whole research and completely changed previous image that Hong Kong had once been the biggest container port all over the world around the year of 2000. Such kind of transition indicated that maritime trade no longer had power to brand its mark on the whole trade in Hong Kong and the correlation between international merchandise trade and international maritime container throughput had become much weaker than before.

Theoretically, average cargo unit price by each transport mode will vary from cargo's ability to bear the transport cost. Generally, air transport will carry high value cargo while land and ocean will carry medium and low price cargo.

The cargo value by air in Table 4.8 was quite higher than by ocean was still not strong enough evidence to demonstrate the change of transport structure in terms of physical volume. However, the ratio of land to ocean transport in Table 4.8 changed from about 1:2 to 2:1 in last two decades. Since both land and ocean transport cargo's average unit value was much similar compared with air transport, the data in Table 4.8 at least gave us a rough image that transport structure had changed sharply in terms of cargo volume.

In China, there was no similar material released by central government. Only Ministry of Transport of PRC released ton-mile data in terms of transport modes and it indicated that waterway transportation still played an important role in merchandise trade. Ton-mile data is the product of cargo's metric tons and transport distance in miles. This indicator reflects transport demand and is always used in international organizations and national macroeconomic statistics.

Japanese government releases international merchandise trade value data in terms of transport modes, but for domestic transport, there is no such kind of statistics material released. MLIT released cargo volume data and showed maritime transport had still occupied about 50% share and taken important position in transport system. In fact, Japan is an archipelago country so that maritime transport plays an important role in its economic life.

Table 4.9 China Cargo Turnover

Year	Total	Railways	Highways	Waterways	Ocean	Civil Aviation	Pipelines
	100 mil. ton-km	100 mil. ton-km	100 mil. ton-km	100 mil. ton-km	100 mil. ton-km	100 mil. ton-km	100 mil. ton-km
1978	9928	5345.2	350.3	3801.8	2487	0.97	430
1980	11629	5717.5	342.9	5076.5	3532	1.41	491
1985	18365	8125.7	1903.0	7729.3	5329	4.15	603
1990	26208	10622.4	3358.1	11591.9	8141	8.18	627
1991	27987	10972.0	3428.0	12955.4	8990	10.10	621
1992	29218	11575.6	3755.4	13256.2	9034	13.42	617
1993	30647	12090.9	4070.5	13860.8	9134	16.61	608
1994	33435	12632.0	4486.3	15686.6	10268	18.58	612
1995	35909	13049.5	4694.9	17552.2	11938	22.30	590
1996	36590	13106.2	5011.2	17862.5	11254	24.93	585
1997	38385	13269.9	5271.5	19235.0	14875	29.10	579
1998	38089	12560.1	5483.4	19405.8	14920	33.45	606
1999	40568	12910.3	5724.3	21262.8	17014	42.34	628
2000	44321	13770.5	6129.4	23734.2	17073	50.27	636
2001	47710	14694.1	6330.4	25988.9	20873	43.72	653
2002	50686	15658.4	6782.5	27510.6	21733	51.55	683
2003	53859	17246.7	7099.5	28715.8	22305	57.90	739
2004	69445	19288.8	7840.9	41428.7	32255	71.80	815
2005	80258	20726.0	8693.2	49672.3	38552	78.90	1088
2006	88840	21954.4	9754.2	55485.7	42577	94.28	1551
2007	101419	23797.0	11354.7	64284.8	48686	116.39	1866
2008	110300	25106.3	32868.2	50262.7	32851	119.60	1944
2009	122133	25239.2	37188.8	57556.7	39524	126.23	2022
2010	141837	27644.1	43389.7	68427.5	45999	178.90	2197
2011	159324	29465.8	51374.7	75423.8	49355	173.91	2885
2012	173804	29187.1	59534.9	81707.6	53412	163.89	3211
2013	168014	29173.9	55738.1	79435.7	48705	170.29	3496

Data source: from National Bureau of Statistics of the People’s Republic of China

Table 4.10 Structure of Japanese Transport Mode

Year	Waterway	Railway	Aviation	Highway	Total
	Thousand Ton	Thousand Ton	Thousand Ton	Thousand Ton	Thousand Ton
2007	3,215,001	50,850	2,328	2,927,928	6,196,107
2008	3,145,777	46,225	2,198	2,808,664	6,002,864
2009	2,636,328	43,251	2,226	2,686,556	5,368,361
2010	2,807,248	43,628	2,195	3,099,833	5,952,904
2011	2,783,949	39,827	1,969	3,187,911	6,013,656
2012	2,851,753	42,340	2,052	3,011,839	5,907,984
2013	2,900,134	44,101	2,174	2,989,496	5,935,905
2014	2,880,597	43,424	2,351	2,934,361	5,860,733

Data Source: from Ministry of Land, Infrastructure, Transport and Tourism, Japan

For Korea, “Assessing the Effect of Trucking Regulation in Korea” released by World Bank Transportation Department (1986) described Korean scenario as “Haul distances are relatively short. The average for inter-urban trucking in only about 100km, and Seoul to Pusan, one of the longest hauls, is under 450 km. Rail is a serious competitor for hauls beyond 150km, and has a 40-50% share of such traffic”.

Basically, 100 kilometer is not a competitive haul distance for waterway transport. The same report further described "Tractor-trailers are …… concentrated in three market segments: commercial carriage of containers in import/export trade, commercial carriage of sheet metal, wire and girders, etc., on flatbeds, and private carriage of bulk cement……. No container is used in domestic movements, nor have swap bodies been introduced." Meanwhile, Hwa-Joong Kim et al. (2008) pointed out that truck should be a main mode to transport international container cargo in Korea.

It was hinted waterway transport did not play an important role in Korea domestic container trade but as a peninsular country, maritime transport definitely played an important role in Korea international trade when North Korea blocked channels to mainland.

However, so far above analysis was only a qualitative analysis. It was still impossible to set up a quantified criterion for sound regression or not. Even in above structure evaluation, it is a quite big challenger to find enough data for our evaluation. For example, it was difficult to find merchandise trade data in container transport mode, so it is impossible for us to achieve the transport structure specifically for container transport. Data series of maritime or waterway transport mode was the sole choice to roughly evaluate container transport share. In this sense, structure evaluation could only be taken as qualitative analysis.

4.3 Correlation Analysis

As correlation is pre-condition of regression analysis, the relevant empirical analysis was made. Correlation coefficients between macro indicators and container throughput segments were listed in Table 4.11 to verify the assumptions of frame development.

Table 4.11 Correlation Coefficient between Macro Indicators and Container Throughput Segments

Correlation Coefficient between	Japan	China	Korea	Hong Kong SAR
GDP and CONT	-0.4559/0.9740	0.9853/0.9940	0.9915/0.9904	0.8355/0.9015
GDP and GC	-	0.9777/0.9919	0.99501/0.99502	-0.5122/-0.5043
(C+I+G) and DC	-0.5333/0.8945	0.9992/0.9966	0.6052/0.6062	-
CA and IC	-0.2081/-0.1336	0.8152/0.6850	0.6904/0.6544	0.2826/0.2793
$(X'+I_m')$ and IC	0.9286/0.9618	0.9884/0.9918	0.9729/0.9764	-0.5625/-0.5342
$(X''+I_m'')$ and IC	0.9720/0.9762	-	-	--
$(C+I+G+X'+I_m')$ and CONT	0.6819/0.9601	0.9921/0.9965	0.9845/0.9853	0.8368/0.8743
$(C+I+G+X'+I_m')$ and GC	-	0.9876/0.9984	0.9894/0.9918	-0.5658/-0.5421
$(C+I+G+X''+I_m'')$ and CONT	0.7682/0.9827	-	-	-

Remark:

1. CONT denotes national or regional gross container throughput including domestic container throughput, international container throughput and international transshipment container throughput.
2. GC denotes gateway container throughput which only includes domestic container throughput (DC) and international container throughput (IC) while excluding international transshipment container throughput (TC)
3. DC denotes domestic container throughput.
4. IC denotes international container throughput.
5. CA denotes current account.
6. $(X'+I_m')$ denotes international merchandise trade.
7. $(X''+I_m'')$ denotes international merchandise trade by container transport released by Ministry of Finance of Japan.
8. Upper part/lower part: upper part denotes correlation coefficient calculated in nominal term; lower part denotes correlation coefficient calculated in real term

It was obvious that some correlation coefficients in Table 4.11 were quite high. It is believed that the first reason for so high correlation coefficients was the development of containerization. As indicated in Section 1.1, maritime container is designed to carry various kinds of commodities, including agriculture, apparel and footwear, automotive, chemicals, dangerous cargo, electronics, fish and seafood, fruit and vegetables, machinery, oversized cargo, protein, pharmaceuticals commodities and so on. With rapid technical development, more and more cargo could be stuffed into container to be carried to every corner of the world. Indeed, maritime container transport carries more than half seaborne trade in value term so that container transport has been connected with our daily life more and more closely.

Past researches also illustrated a lot of cases that port throughput was closely connected with macro indicators. For example, Martin Stopford (2009) made use of linear function to make regression analysis between world GDP and world seaborne trade in his classical textbook. The correlation coefficients between world GDP and seaborne trade was higher than 0.99 from the year of 1982 to 1995.

Container throughput researches also always indicate high correlation coefficient with macro indicators since container throughput is just one of throughput statistics which focuses on maritime container business. Masayoshi Kubo et al. (2000) found high coefficient of determinations between national or regional container throughput and GDP in Asia in below Figure A. Many countries' coefficients of determination between container throughput and GDP were higher than 0.90 or even 0.99. For example, the coefficient between Indonesia's container throughput and GDP was 0.9944 from 1975 to 1997 when the sum of China mainland and Hong Kong's container throughput had high coefficient of determination 0.9986 with China mainland's GDP. Since the coefficient of determination is the square of the correlation coefficient, we can assume high correlation between container throughput and macro economy for these countries or regions.

Secondly, Japan, China and Korea were strong in manufacturing industries and heavily relied on export industry during our research period so that these three samples provided some high correlation coefficients in Table 4.11. However, Hong Kong did not indicate high correlation between container throughput and macro indicators since its industry, trade and transport structure did not support such kind of correlation.

Overall, as per our methodology study in previous part, container throughput is connected with macro economy and its industry, trade and transport structure. Thus, it is normal that some coefficients in Table 4.11 indicated high correlation while some other regional economy did not have high correlation between container throughput and macro indicators.

4.3.1 Correlation between GDP and Container Throughput

Though Chinese and Korean nominal GDP had high correlation with container throughput, Japanese coefficient was only -0.4559 that means both data series were not correlated with each other, which was in line with our argument on GDP was not always a suitable variable for container throughput analysis. Hong Kong provided same evidence with correlation coefficient -0.5122.

4.3.2 Correlation between Domestic Demand and Domestic Container Throughput

The coefficient between nominal domestic demand and domestic container throughput in Japan was -0.5333 demonstrated independence between domestic demand and container throughput. However, the coefficient between same data series in real term in Japan was 0.8945 which indicated contribution of deflator process and support our methodology.

The coefficient of China also supported our argument while the Korea's was 0.6062 in real termand indicated a lower correlation trend after year of 2000. Since Korea is a geographically peninsula country with narrow passage between east and west coast, so most domestic trade are carried by trucks rather than uneconomical maritime container transport which provides a reasonable explanation for the lower coefficient. There was no coefficient for Hong Kong calculated since no domestic maritime container transport happened.

4.3.3 Correlation between Current Account and International Container Throughput

The coefficient of China was 0.8152 while Japanese was -0.2081，Korean was 0.6904 and Hong Kong was 0.2820, which meant all coefficients were low. However, it just supported our argument. From the viewpoint of trade data, the current account stands for net export amount while container throughput represents the sum of import and export cargo volume, the economic facts behind the data do not match with each other at all.

4.3.4 Correlation between International Merchandise Trade and International Container Throughput

The coefficients between international container throughput and real international merchandise trade data of Japan, China and Korea were 0.9618, 0.9918 and 0.9764 respectively higher than nominal trade data's coefficients.

Normally the figures of international merchandise trade released by government are integral data by all kinds of transport modes as we used in this study. Fortunately, Japanese Ministry of Finance released the data of international trade by container transport mode which enabled us to verify the correlation result of above. The coefficient of the nominal trade value by container transport was 0.9720 and that of the real trade value counterpart was 0.9762 which supported first assumption while the latter coefficient was higher than 0.9618 previously processed by integral trade data.

Hong Kong was another case with coefficient -0.5342. Re-exports trade held 85 percent international merchandise trade in 2013 compared with 67 percent in 1992. Just as Hiroshi Hoshino (2010) described in his paper, Hong Kong was positioned as a gateway and re-exporter of Chinese cargo. Since re-export dominated Hong Kong's local trade and it connects with lots of countries, the total amount of re-exports was a mixture with many countries' macroeconomic characteristics so that it was difficult to maintain stable relativity with container throughput.

4.3.5 Correlation between Gross Demand and Gateway Container Throughput

The coefficients of Japan, China and Korea were 0.9601, 0.9984 and 0.9918 which supported new frame while the coefficient of international trade data by container transport with ($C+I+G+X''+I_m''$) of Japan was 0.9827 which supported third assumption stated in Part 3. As Japanese transshipment volume was quite small, it was ignored and total container throughput was taken as gateway container throughput.

As expected, the coefficient in terms of Korea's gross container throughput was 0.9853 which was lower than that of gateway container throughput 0.9918. The comparison evidently supported transshipment container throughput should be dealt carefully when it was big enough.

Meanwhile, as mentioned in Part 3.3.2, the cargo volume of domestic feeder for international trade was quite big in China while its international transshipment volume could be ignored, the correlation analysis was made once again between gross demand and container throughput after removing domestic feeder cargo volume. The coefficient was 0.9984 which was higher than correlation coefficient between gross demand and gross container throughput in China. The outcome evidently supported our assumptions.

The coefficient of Japan in nominal term and Hong Kong did not support the assumptions due to low correlation coefficients which also indicated that the high correlation coefficients in this Japan, China and Korea were occasional and supported data source independence.

4.3.6 Correlation Coefficient with Nominal and Real Macro Data

Most correlation coefficients with real term were higher than nominal term which indicated real macro data was stably correlated with container throughput data than nominal macro data. The only one exception in the empirical analysis was correlation coefficient between domestic demand (C+I+G) and domestic container throughput (DC) in China. However, the difference between nominal and real term coefficients was quite small and coefficients with real term were high enough to indicate correlation with domestic demand and domestic production data. As a whole, coefficients with real macro data were stably higher than the same with nominal macro data.

4.4 Linear Regression

After most coefficients evidently supported new frame, the simplest linear model was employed to make a trial regression analysis.

Firstly, a linear regression model with two independent variables including domestic demand ($C + I + G$) and international merchandise trade ($X' + Im'$) was established based on function (4.7) as below:

$$GC = a(C + I + G) + b(X' + Im') + \text{c} \tag{4.7}$$

a and b: parameter
c: residuals.

All three countries' correlation coefficient were over 0.92 but the data series of domestic demand and international merchandise trade were found with high correlation for all three countries so that binary linear model was given up in this empirical analysis. However, it did not mean the frame of function (4.7) was not workable if exact data series is found. Hong Kong's linear regression model with two independent variables was not successful due to its lower correlation coefficient.

And then, linear regression model was successfully established between gross demand and container throughput based on function (4.8). Since data series of domestic demand and international merchandise trade were highly correlated, below function (4.8) was created as per function (3.9) in linear regression.

$$GC = d(C + I + G + X' + Im') + \text{e} \tag{4.8}$$

d: parameter
e: residuals.

Figure 4.1 to Figure 4.4 showed the details by use of EXCEL 2007 data analysis tool with successful t-test and F-test results but Hong Kong was still an exception with low correlation coefficient.

In consideration of industry, trade and transport structure reviewed in Section 4.2, Hong Kong's macro economy hardly connected with physical industries as well as physical container transport while Hong Kong's service industries was dominantly strong and re-export was quite big enough. Meanwhile, ocean transport only occupied 20.2% in the value of Hong Kong's international merchandise trade in 2013 which indicated transport structure changed sharply from 1993 to 2013. Overall, industry structure, trade structure and transport structure did not support high correlation between Hong Kong's macro economy and container throughput so that the relevant correlation coefficient was low.

SUMMARY OUTPUT								**Japan**
								CONT=a(C+I+G+X'+Im')+c
Regression Statistics								Data in Real Term
Multiple R	0.960060252							
R Square	0.921715688							
Adjusted R Square	0.915693818							
Standard Error	735052.8776							
Observation	15							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	8.26995E+13	8.26995E+13	153.0613689	1.44805E-08			
Residual	13	7.02394E+12	5.40303E+11					
Total	14	8.97234E+13						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-10673878.8	2399926.042	-4.447586557	0.000657527	-15858603.79	-5489153.813	-15858603.79	-5489153.813
X Variable 1	47.81641536	3.864953016	12.37179732	1.44805E-08	39.46669202	56.1661387	39.46669202	56.1661387

Figure 4.1 Linear Regression Analysis of Japan by Expenditure Frame

SUMMARY OUTPUT								**China**
								GC=a(C+I+G+X'+Im')+c
Regression Statistics								Data in Real Term
Multiple R	0.998410079							
R Square	0.996822687							
Adjusted R Square	0.996610866							
Standard Error	336.2704102							
Observation	17							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	532140677.1	532140677.1	4705.969961	3.73871E-20			
Residual	15	1696166.831	113077.7887					
Total	16	533836843.9						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-3532.550894	197.825883	-17.85686909	1.61929E-11	-3954.206781	-3110.895008	-3954.206781	-3110.895008
X Variable 1	0.821464023	0.011974682	68.6000726	3.73871E-20	0.795940593	0.846987452	0.795940593	0.846987452

Figure 4.2 Linear Regression Analysis of China by Expenditure Frame

SUMMARY OUTPUT								**Korea**
								GC=a(C+I+G+X'+Im')+c
Regression Statistics								Data in Real Term
Multiple R	0.991801099							
R Square	0.98366942							
Adjusted R Square	0.982959395							
Standard Error	536900.2688							
Observation	25							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	3.99358E+14	3.99358E+14	1385.400695	4.66835E-22			
Residual	23	6.63002E+12	2.88262E+11					
Total	24	4.05988E+14						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-1715798.177	283852.2654	-6.044687276	3.64528E-06	-2302991.323	-1128605.031	-2302991.323	-1128605.031
X Variable 1	6.520536927	0.175184492	37.22097118	4.66835E-22	6.158140196	6.882933657	6.158140196	6.882933657

Figure 4.3 Linear Regression Analysis of Korea by Expenditure Frame

SUMMARY OUTPUT								**Hong Kong**
								GC=a(C+I+G+X'+Im')+c
Regression Statistics								Data in Real Term
Multiple R	0.542112064							
R Square	0.29388549							
Adjusted R Square	0.26026099							
Standard Error	85.01714268							
Observation	23							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	63173.55447	63173.55447	8.740218778	0.007535394			
Residual	21	151786.2055	7227.914549					
Total	22	214959.76						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	862.7444298	47.6764983	18.09580109	2.74586E-14	763.5957243	961.8931354	763.5957243	961.8931354
X Variable 1	-2.18781E-05	7.40028E-06	-2.956386101	0.007535394	-3.72678E-05	-6.48836E-06	-3.72678E-05	-6.48836E-06

Figure 4.4 Linear Regression Analysis of Hong Kong by Expenditure Frame

Figure 4.5 to Figure 4.7 were simulated by EXCEL 2007 tool for linear function curves of three countries which evidently supported new analysis frame well. All the curves fit the original data series and indicated the high correlation.

Similarly, binary linear regression function and linear regression function was created in production frame while production frame's empirical analysis outcome was almost same as expenditure frame.

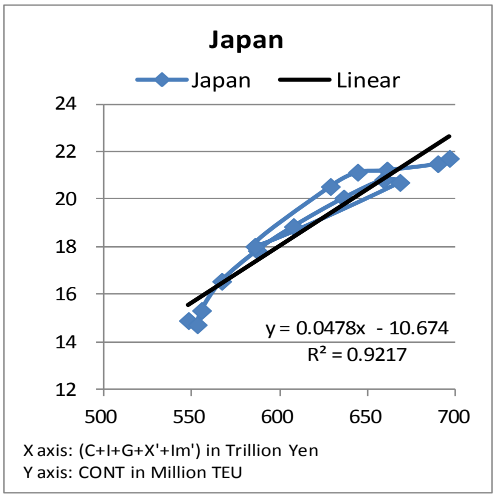


Figure 4.5 Linear Function Simulation of Japan

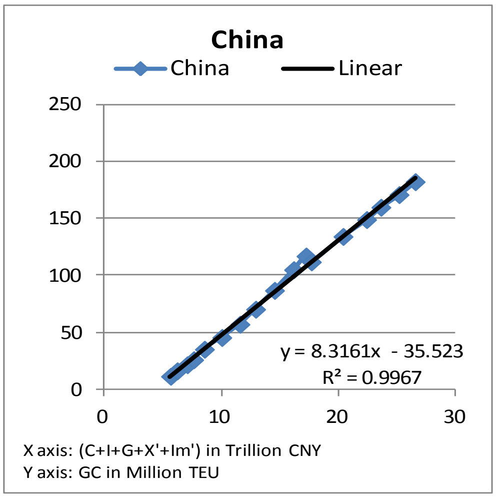


Figure 4.6 Linear Function Simulation of China

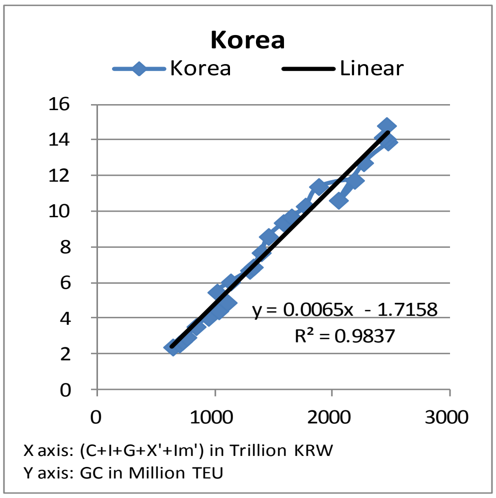


Fig 4.7 Linear Function Simulation of Korea

4.5 China-plus-Hong Kong Case

In general, Hong Kong did not support the frame as well as any assumption in this empirical analysis but qualitative structure evaluation provided the explanation. The structure evaluation made above indicated that service trade and re-export trade dominated regional economy while maritime transport faded from its peak in the transport structure in Hong Kong and lead to failed correlation analysis.

However, as major re-exports trade and transshipment cargo was from or to China, further empirical analysis was made with the case by China-plus-Hong Kong. If China mainland and Hong Kong were dealt as an integral party in this empirical analysis, as per new frame, two variables domestic demand and international merchandise trade should correlate to domestic and international container throughput while gross demand correlated to gateway container throughput in expenditure frame.

Of course, below adjustment was made for regression analysis:

(1) Currency should be unified and CNY is used in later empirical analysis since the economic scale of China mainland is quite bigger than Hong Kong;

(2) Trade between China mainland and Hong Kong should be regarded as domestic trade;

(3) Container trade between China mainland and Hong Kong should be regarded as domestic container throughput;

(4) Transshipment traffic from China to Hong Kong was just regarded as domestic feeder service for international trade and would not be calculated into gateway container throughput.

The international merchandise trade data between China and Hong Kong was quickly found from Hong Kong Annual Digest of Statistics, but container traffic data could not be found respectively. Hong Kong ADS only provided container traffic data between China and Hong Kong but without identifying direct trade and transshipment traffic.

In the meantime, Hong Kong Shipping Statistics provided data in terms of cargo weight as Table 4.12.

Table 4.12 Waterborne International & Transshipment Cargo Throughput between Hong Kong and China Mainland

Item	Import cargo from China	Inward Transshipment from China	Export cargo to China	Outward Transshipment to China
Unit	1000MT	1000MT	1000MT	1000MT
1998	17806	7234	20769	9417
1999	16893	9267	14920	12404
2000	19334	10805	14830	15655
2001	22422	10958	13013	18776
2002	24983	13519	12318	21673
2003	24723	17431	13368	23838
2004	22313	21417	13653	24680
2005	26063	22741	15057	24954
2006	26445	24587	18290	24908
2007	23528	28431	16399	26410
2008	23544	30783	25630	25990
2009	22684	23539	26221	29152
2010	26591	30849	25381	29446
2011	24314	33903	25888	30138
2012	24253	31164	23601	30078
2013	36365	31046	23915	30098
2014	63789	30482	25036	29949

Data source: from Hong Kong Shipping Statistics, 1998-2014

From Table 4.12, it is possible to get the share of direct trade and transshipment business both for import and export cargo including container traffic. To separate the container traffic data into direct trade and transshipment business, container traffic share of direct trade and transshipment business was supposed to be same as above share. Thus, direct trade and transshipment container traffic data was calculated and Table 4.13 was developed to further empirical analysis.

By use of above container throughput data, the correlation coefficients were calculated and shown in Table 4.15. The correlation coefficient between adjusted domestic demand and domestic container throughput was 0.9969 and coefficient between adjusted international merchandise trade and international container throughput was 0.9915 while coefficient between adjusted gross demand and gateway container throughput was 0.9983. All coefficients in production approach showed high correlation between macro indicators and container throughput segments.

Same as before, linear regression model was created on basis of function (4.8) and result was shown in Figure 4.8 with good significant test.

4.6 Brief Conclusion

This research made the first attempt to make the correlation analysis between GDP sectors, such as domestic demands and international merchandise trade, and container throughput segments in terms of trade nature, namely DC, IC and TC, in order to match the economic facts as much as possible.

This was also the first time to remove transshipment volume from gross container throughput before making the correlation and regression analysis between gateway container throughput and national macro indicators. The difference between nominal and real term's influence on correlation coefficients was also checked and indicated contribution of deflator.

The empirical analysis in this part clearly indicated that GDP was not a suitable independent variable to explain container throughput while gross demand had high correlation with gateway container throughput. Meanwhile, empirical analysis illustrated real macro data had higher correlation with container throughput than nominal macro data.

Hong Kong was a special case which strengthened the importance of economic structure evaluation and integrated study with both quantitative and qualitative analysis would enhance the sound regression analysis. And China-plus-Hong Kong case further supported the data with more container trade facts had higher correlation with container throughput.

Table 4.13 Adjusted Real Macro Indicators in Expenditure Frame
and Container Throughput Data (China-plus-HK)

Item	Adjusted Real (C+I+G)	Adjusted Real ($X'+I_m'$)	Adjusted Real Gross Demand	Adjusted DC	Adjusted IC	Adjusted GC
Unit	Billion CNY	Billion CNY	Billion CNY	10000TEU	10000TEU	10000TEU
1998	9621	3423	15274	281	1652	1927
1999	10265	3725	16342	393	2201	2438
2000	10951	4722	18559	522	2405	3012
2001	11827	4778	19470	665	2646	3390
2002	12766	5579	21557	887	3336	4326
2003	14043	7268	25241	1095	4138	5364
2004	15392	9111	29322	1323	5535	6563
2005	16643	10474	32578	1751	5998	7870
2006	18522	11916	36532	2325	7040	9528
2007	20175	12854	39335	2883	8206	11275
2008	22148	12829	40981	3556	8632	12445
2009	25104	10778	41262	3880	7906	11819
2010	27256	13436	47295	4643	9407	14093
2011	29814	14657	51140	5593	9899	15539
2012	32399	14775	53950	6435	10053	16546
2013	35080	15343	57302	7288	10263	17631
2014	37633	15590	59984	7918	10748	18780

Data source: edited by data from China and Hong Kong government

Table 4.14 Adjusted Real Macro Indicators in Production Frame
and Container Throughput Data (China-plus-HK)

Item	Adjusted Real Domestic Production	Adjusted Real Int'l Merchandise Trade	Adjusted Real Gross Demand	Adjusted Sum of DC	Adjusted Sum of IC	Adjusted Sum of GC
Unit	Billion CNY	Billion CNY	Billion CNY	10000TEU	10000TEU	10000TEU
1998	5283	3423	8706	281	1652	1927
1999	5628	3725	9353	393	2201	2438
2000	6088	4722	10810	522	2405	3012
2001	6414	4778	11193	665	2646	3390
2002	6771	5579	12350	887	3336	4326
2003	7535	7268	14804	1095	4138	5364
2004	8413	9111	17524	1323	5535	6563
2005	8853	10474	19327	1751	5998	7870
2006	9570	11916	21486	2325	7040	9528
2007	10504	12854	23358	2883	8206	11275
2008	11708	12829	24537	3556	8632	12445
2009	13055	10778	23833	3880	7906	11819
2010	14840	13436	28276	4643	9407	14093
2011	16535	14657	31192	5593	9899	15539
2012	17280	14775	32055	6435	10053	16546
2013	18125	15343	33468	7288	10263	17631
2014	18643	15590	34234	7918	10748	18780

Data source: edited by data from China and Hong Kong government

Table 4.15 Correlation Coefficient between Macro Indicators and Container Throughput Segments

Correlation Coefficient between	China-plus-Hong Kong (Real Term)
GDP and GC	0.9919
$(C+I+G+X'+I_m')$ and GC	0.9983
(C+I+G) and DC	0.9969
(C+I+G) and GC	0.9852
CA and IC	-0.1887
$(X' + I_m')$ and IC	0.9915

SUMMARY OUTPUT | **China-plus-Hong Kong** | **GC=a(C+I+G+X'+Im')+c** | Data in Real Term

Regression Statistics	
Multiple R	0.998279034
R Square	0.996561031
Adjusted R Squar	0.996331766
Standard Error	344.7456476
Observation	17

ANOVA

	df	SS	MS	F	Significance F
Regression	1	516611923.3	516611923.3	4346.771806	6.76915E−20
Residual	15	1782743.423	118849.5615		
Total	16	518394666.7			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	−4051.220002	222.760401	−18.18644599	1.24491E−11	−4526.022556	−3576.417449	−4526.022556	−3576.417449
X Variable 1	0.381798033	0.005790956	65.93005238	6.76915E−20	0.369454902	0.394141163	0.369454902	0.394141163

Fig 4.8 Linear Regression Analysis of China-plus-Hong Kong by Expenditure Frame

Part 5 Empirical Structural Analysis

"……which means in a study so complex as economics, in which we cannot hope to make completely accurate generalizations, the factors whose changes mainly determine our quaesitum. Our final task might be to select those variables which can be deliberately controlled or managed by central authority in the kind of system in which we actually live……"

---John Maynard Keynes, The General Theory of Employment, Interest, and Money

The aim of structural analysis is to grasp generation mechanism between container throughput and macro economy structure. The empirical analysis in this part was based on Japanese 2005 and 2011 Input-Output Tables to make structural analysis on Japanese international merchandise trade and international container throughput. Meanwhile, comparison between Stage I from 2005 to 2010 and Stage II from 2011 to 2015 was made to check methodology's practicability under different economic structure.

5.1 Data Source

In order to ensure consistence and strictness, all the data series adopted in this empirical analysis were released from Japanese government in below four data sources:

I. Input-output Table, released by Ministry of Internal Affairs and Communications, Japan (https://www.estat.go.jp/statsearch/files?page=1&toukei=00200603&kikan=00200&result_page=1)
II. Macroeconomic Statistics in Industry Wise, released by Cabinet Office, Japan (http://www.esri.cao.go.jp/jp/sna/data/data_list/kakuhou/files/h27/h27_kaku_top.html)
III. Trade Statistics of Japan, developed by Ministry of Finance, Japan (http://www.customs.go.jp/toukei/srch/index.htm)
IV. Yearbook of Port Statistics 2005-2015, released by Ministry of Land, Infrastructure, Transport and Tourism, Japan (http://www.mlit.go.jp/k-toukei/cgi-bin/search.cgi)

From Data Source I, intermediate output, final demand and gross output in 2005 and 2011 were available while macro economy was divided into 13 sectors from Agriculture, Mining to Others. The Leontief inverse matrix of equation (2.7) was also accessible in this data source (See Appendix 7).

From Data Source II (See Appendix 9) , time series data of gross output, intermediate output and GDP from 1994 to 2015 in real term for 16 industrial departments were accessible. Year of 2011 was set to be reference year for chain linked time series data. By use of this data and 2011 Input-output Table, it was possible to simulate gross output from 2005 to 2015.

From Data Source III, annual international trade statistics could be secured based on The Harmonization System Code (HS-Code) (See Appendix 8) developed by World Customs Organization (WCO) to get international trade data including cargo weight and correspondent value.

From Data Source IV, weight and amount of international container throughput could be found.

5.2 Gross Output

Both 2005 and 2011 Input-Output Table provided two kinds of data series which included 13 and 37 industries individually. In consideration of Data Source II included 16 industries, this study chose Data Source I with 13 industrial departments to match macroeconomic statistics more exactly.

"Hotel & Restaurant Service", "Scientific & Technical Service", "Education" and "Health care & Social Welfare" industrial departments in Data Source II were combined into "Services" industry when

"Other Services" department was regarded as "Activities not elsewhere classified" to match with industries in Data Source I (See Table 5.1).

Table 5.1 Industries Combination to Adapt to Input-output Table

Macroeconomic Statistics by 16 Industries	Adjusted Macroeconomic Statistics by 13 Industries	Input-output Table by 13 Industries
(1) Agriculture, forestry and fishery	(1) Agriculture, forestry and fishery	1. Agriculture, forestry and fishery
(2) Mining	(2) Mining	2. Mining
(3) Manufacturing	(3) Manufacturing	3. Manufacturing
(4) Electricity, gas and water supply	(5) Construction	4. Construction
(5) Construction	(4) Electricity, gas and water supply	5. Electricity, gas and water supply
(6) Commerce	(6) Commerce	6. Commerce
(7) Transport & postal services	(10) Finance & Insurance	7. Financial & Insurance
(8) Hotel & restaurant	(11) Real Estate	8. Real Estate
(9) Information & communications	(7) Transport & postal services	9. Transport & postal services
(10) Finance & Insurance	(9) Information & communications	10. Information & communications
(11) Real Estate	(13) Public administration	11. Public administration
(12) Scientific & technical Service	(8) Hotel & restaurant	12. Services
(13) Public administration	(12) Scientific & technical Service	
(14) Education & research	(14) Education & research	
(15) Health Care & social Welfare	(15) Health Care & social Welfare	
(16) Other Services	(16) Other Services	13. Activities not elsewhere classified

Time-series data of gross output from the year of 2005 to 2015 were listed as Table 5.2. The data used in Table 5.2 were in real term while input-output table by producer's price was selected to match physical production as much as possible.

Table 5.2 Simulated Gross Output from 2005 to 2015

Industry	Gross Output		
	2005	2006	2007
Agriculture, forestry and fishery	12,493.4	12,264.7	12,541.5
Mining	1,178.0	1,093.6	1,029.0
Manufacturing	304,399.7	314,836.3	327,882.0
Construction	66,063.2	64,540.3	59,919.0
Electricity, gas and water supply	26,269.8	26,063.8	26,501.6
Commerce	96,371.8	94,311.4	93,187.5
Financial & Insurance	35,399.6	35,945.2	37,517.8
Real Estate	63,356.9	64,780.6	66,062.0
Transport & postal services	52,478.6	53,732.7	54,986.8
Information & communication	41,590.4	43,021.4	44,221.6
Public administration	38,577.7	38,104.8	38,262.4
Services	223,831.5	227,150.6	231,272.5
Activities not elsewhere classified	4,348.9	4,434.1	4,484.2

(Continued)

Industry	Gross Output		
	2008	2009	2010
Agriculture, forestry and fishery	12,649.8	12,433.2	12,252.6
Mining	937.8	856.5	829.2
Manufacturing	322,083.9	267,581.9	297,152.1
Construction	56,033.0	53,039.6	50,991.6
Electricity, gas and water supply	26,398.6	25,342.6	26,244.0
Commerce	93,281.2	88,223.8	92,157.3
Financial & Insurance	33,506.0	32,896.2	32,543.2
Real Estate	67,201.0	68,482.4	69,977.3
Transport & postal services	54,070.3	48,909.3	49,439.9
Information & communication	44,914.0	44,406.2	45,283.3
Public administration	37,947.2	38,498.9	39,247.6
Services	231,727.9	222,234.1	222,447.2
Activities not elsewhere classified	4,554.4	4,674.6	4,819.9

(Continued)

Industry	Gross Output		
	2011	2012	2013
Agriculture, forestry and fishery	12,036.0	12,072.1	12,192.5
Mining	760.0	757.0	775.2
Manufacturing	289,904.5	294,832.9	291,933.8
Construction	52,514.5	54,615.1	59,919.0
Electricity, gas and water supply	25,754.7	25,239.6	24,801.8
Commerce	93,655.8	95,903.5	98,151.3
Financial & Insurance	32,093.9	32,446.9	34,597.2
Real Estate	71,187.5	71,899.4	72,896.0
Transport & postal services	48,234.0	49,391.6	49,536.3
Information & communication	46,160.3	47,037.3	48,099.0
Public administration	39,405.2	39,405.2	40,035.7
Services	222,958.2	225,129.5	225,976.5
Activities not elsewhere classified	5,010.3	5,215.7	5,341.0

(Continued)

Industry	Gross Output	
	2014	2015
Agriculture, forestry and fishery	12,011.9	11,795.3
Mining	764.6	745.6
Manufacturing	297,152.1	296,862.2
Construction	60,339.2	60,601.7
Electricity, gas and water supply	24,621.5	24,389.7
Commerce	94,030.4	94,217.7
Financial & Insurance	34,404.7	36,234.0
Real Estate	73,607.9	74,177.4
Transport & postal services	50,501.0	50,501.0
Information & communication	48,329.8	49,253.0
Public administration	39,759.8	39,917.5
Services	224,709.8	226,306.1
Activities not elsewhere classified	5,406.1	5,621.6

(in 1 billion yen and by producer's price)

5.3 Container Cargo Weight and Value

Container cargo's weight and value was illustrated in below Table 5.3 and Table 5.4 by use of Data Source III. HS code 01-24 stands for international merchandise trade of primary industry while HS code 25-38 stands for cargo of mining industry. Other HS code after that mainly stands for manufactured or processed cargo.

Table 5.3 International Trade Containerized Cargo Weight and Value in 2005

HS CODE	Commodities	Weight (KG)	Value (1000 Yen)
01-05	Animal products	1.63E+10	5.00E+09
06-15	Vegetable products		
16-24	Prepared foodstuffs & etc.		
25-28	Mineral products including crude oil and etc.	Mainly in bulk	
29	Organic chemicals		
30-38	Fertilizer & chemicals		
39	Plastics and articles thereof		
40	Rubber and articles thereof		
41-43	Handbags and similar containers, Leather and etc.	3.38E+08	5.79E+08
44-49	Wood, articles of wood and pulp	Mainly in bulk	
50-53	Textiles & Textile articles	1.83E+09	1.21E+09
54-55	Man-made fibers		
56-59	Carpet, textile fabrics and etc.		
60-63	Knitted fabrics and other made up textile articles	1.98E+09	3.21E+09
64-67	Footwear, headwear, umbrellas and etc.		
68	Stone, plaster, cement and etc.	Mainly in bulk	
69-70	Ceramic and glass products	1.95E+09	8.28E+08
71	Pearls, Precious stones, metals and etc.	Mainly by air	
72-73	Iron, steel and articles of iron or steel	Mainly in bulk	
74-83	Copper, nickel and other base metal	6.42E+09	2.94E+09
84	Machinery & parts	1.31E+10	2.66E+10
85	Electrical machinery and equipment		
86-89	Vehicles, aircraft, vessels and associated transport equipment	Mainly by roro vessel or self-propelled	
90-93	Optical, watches, musical instruments, arms and ammunitions	Mainly by air or by conventional vessels	
94-97	Works of art, collections pieces	Mainly by air	
00	Re-export articles	Neglectable in Japan	

Table 5.4 International Trade Containerized Cargo Weight and Value in 2011

HS CODE	Commodities	Weight (KG)	Value (1000 Yen)
01-05	Animal products	1.54E+10	5.56E+09
06-15	Vegetable products		
16-24	Prepared foodstuffs & etc.		
25-28	Mineral products including crude oil and etc.	Mainly in bulk	
29	Organic chemicals		
30-38	Fertilizer & chemicals		
39	Plastics and articles thereof		
40	Rubber and articles thereof		
41-43	Handbags and similar containers, Leather and etc.	3.10E+08	5.23E+08
44-49	Wood, articles of wood and pulp	Mainly in bulk	
50-53	Textiles & Textile articles	1.70E+09	1.14E+09
54-55	Man-made fibers		
56-59	Carpet, textile fabrics and etc.		
60-63	Knitted fabrics and other made up textile articles	2.21E+09	3.45E+09
64-67	Footwear, headwear, umbrellas and etc.		
68	Stone, plaster, cement and etc.	Mainly in bulk	
69-70	Ceramic and glass products	1.46E+09	8.92E+08
71	Pearls, Precious stones, metals and etc.	Mainly by air	
72-73	Iron, steel and articles of iron or steel	Mainly in bulk	
74-83	Copper, nickel and other base metal	6.08E+09	3.39E+09
84	Machinery & parts	1.51E+10	2.58E+10
85	Electrical machinery and equipment		
86-89	Vehicles, aircraft, vessels and associated transport equipment	Mainly by roro vessel or self-propelled	
90-93	Optical, watches, musical instruments, arms and ammunitions	Mainly by air or by conventional vessels	
94-97	Works of art, collections pieces	Mainly by air	
00	Re-export articles	Neglectable in Japan	

5.4 Unit Weight of Container Cargo

By use of "Table of Container & Chassis in ton wise" and "Table of Container & Chassis Throughput" in Data Source IV, unit weight of container cargo in international trade could be calculated in below Table 5.5.

Table 5.5 International Trade Container Unit Weight

Year	Weight (Metric Ton)	Throughput (TEU)	Unit Weight (MT/TEU)
2005	231,720,000	15,732,277	14.73
2006	244,604,502	16,616,471	14.72
2007	253,306,164	17,138,769	14.78
2008	251,394,888	17,129,122	14.68
2009	216,357,667	14,744,605	14.67
2010	250,012,253	16,847,612	14.84
2011	253,430,635	17,503,465	14.48
2012	250,344,847	17,519,810	14.29
2013	253,187,596	17,744,935	14.27
2014	255,250,483	17,924,296	14.24
2015	248,228,344	17,285,182	14.36

The average unit weight of containerized cargo was quite stable both in Stage I and Stage II for international trade and this unit weight would be used in below research.

5.5 Conversion Coefficient

In Section 3.4.1, L_{cont}, L_{dc} and L_{ic} were defined as conversion coefficients from gross output to gateway container throughput, domestic container throughput (*DC*) and international container throughput (IC) so that it was necessary to analyze Japanese conversion coefficient from industry's output or product's characteristics.

In Section 5.1, Input-Output Table published by Japanese government released 13 industries as below:

1. Agriculture, Forestry and Fishery
2. Mining
3. Manufacturing
4. Construction
5. Electricity, Gas and Water Supply
6. Commerce
7. Financial & Insurance
8. Real Estate
9. Transport & Postal Services
10. Information & Communication
11. Public Administration
12. Services
13. Activities Not Elsewhere Classified

Obviously, Agriculture, Forestry and Fishery industry and Manufacturing industry are connected with physical output or product which demands container transport service. It is necessary to check its conversion coefficient by use of Japanese statistics data.

For Mining industry, the most output are raw materials, for example, iron ore, coal and crude oil. Just like we pointed out in Section 2.3.2, such kind of mining products are too cheap to afford container transport cost and are basically carried by bulk or tanker vessel. Though container throughput carries more than half of global seaborne trade in value term, bulk and tanker transport still carry most part of global seaborne trade in weight term.

Meanwhile, Japanese mining industry is not well developed and its scale is very small as per Input-Output Table in Figure 2.3. Thus, it is possible to assume Mining industry's conversion coefficient as zero.

For Construction industry, it makes use of engineers' intelligence and labor to build factory, mansion, sport stadium and so on. Basically, its products cannot be moved and will not be carried by container if container's size and payload (weight) limitation is further considered. Thus, the conversion coefficient of Construction industry is also assumed to be zero.

For Electricity, Gas and Water Supply industry, its products or outputs are mainly carried by pipelines and electricity power network so that it will not generate container throughput demand.

From Commerce industry to Services Industry, they all belong to the service industry in a more macro sense without any physical output so that obviously their conversion coefficients are zero.

Finally, for Activities Not Elsewhere Classified industry, its business scale is so small in whole economy compared with other main industries that it can be negligible. Its coefficient in this study is also supposed to be zero.

Overall, after studying 13 industries in Japanese Input-Output Table, only Agriculture and Manufacturing industry were assumed to generate container transport demand directly.

Therefore, function (3.14) was developed into function (5.1) as below:

$$IC = L_{ic} \cdot X = [l_{\mathrm{a}} \quad 0 \quad l_{\mathrm{m}} \quad 0 \quad \cdots \quad 0] \cdot \begin{bmatrix} \mathrm{x_a} \\ \mathrm{x_{mi}} \\ \mathrm{x_m} \\ \mathrm{x_c} \\ \vdots \\ \mathrm{x_o} \end{bmatrix} = l_{\mathrm{a}} \cdot \mathrm{x_a} + l_{\mathrm{m}} \cdot \mathrm{x_m} \tag{5.1}$$

l_{a}: conversion coefficient between Agriculture industry output and its container throughput.

$\mathrm{x_a}$: Agricultural industry output.

l_{m}: conversion coefficient between Manufacturing industry output and its container throughput.

x_m: Manufacturing industry output.

In order to secure l_a and l_m, this study took the same methodology used by Ma (2006) to convert value term into TEU term. Firstly, containerized cargo weight and value was found in Table 5.3; secondly, unit weight of container cargo was calculated in Table 5.5 as 14.73 metric tons in 2005, thirdly, by use of empirical data in Table 5.3 and Table 5.5, l_a and l_m in 2005 was calculated as equation (5.2) and (5.3).

$$l_a = \frac{\text{Cargo Weight}}{(\text{Unit Weight per TEU})\times\text{Cargo Value}} = \frac{1.63\text{E}+10}{(14.74\cdot1000)\cdot(5.00\text{E}+09)\cdot1000} = 2.22\text{E}-07 \text{ (TEU/YEN)} \quad (5.2)$$

$$l_m = \frac{\text{Cargo Weight}}{(\text{Unit Weight per TEU})\times\text{Cargo Value}} = \frac{2.56\text{E}+10}{(14.74\cdot1000)\cdot(3.54\text{E}+10)\cdot1000} = 4.92\text{E}-08 \text{ (TEU/YEN)} \quad (5.3)$$

Then, international container throughput from 2005 to 2010 was developed as function (5.4):

$$IC = l_a \cdot x_a + l_m \cdot x_m = (2.22\text{E}-07)\cdot x_a + (4.92\text{E}-08)\cdot x_m \quad (5.4)$$

By use of same methodology, function of international container throughput from 2011 to 2015 was developed as function (4.5).

$$IC = l_a \cdot x_a + l_m \cdot x_m = (1.92\text{E}-07)\cdot x_a + (5.28\text{E}-08)\cdot x_m \quad (5.5)$$

It was easy to understand two sets of l_a and l_m in 2005 and 2011 were different since macroeconomic structure changed from Stage I to Stage II. By use of function (5.4) and (5.5), simulation was made for both Stage I and Stage II to verify proposed methodology. Table 5.6 and Table 5.7 illustrated difference between simulated outcome and actual throughput.

Table 5.6 Simulated International Container Throughput
(by conversion coefficient in 2005, $l_a = (2.22\text{E}-07)$ and $l_m = (4.92\text{E}-08)$)

Year	x_a	x_m	Simulated Throughput	Official Throughput	Difference (Percent Error)
	Bn Yen	Bn Yen	TEU	TEU	%
2005	12,493	304,400	17,730,510	15,732,277	12.70
2006	12,265	314,836	18,192,830	16,616,471	9.49
2007	12,542	327,882	18,895,403	17,138,769	10.25
2008	12,650	322,084	18,634,403	17,129,122	8.79
2009	12,433	267,582	15,907,451	14,744,605	7.89
2010	12,253	297,152	17,320,911	16,847,612	2.81

Table 5.7 Simulated International Container Throughput
(by conversion coefficient in 2011, $l_a = (1.92\text{E}-07)$ and $l_m = (5.28\text{E}-08)$)

Year	x_a	x_m	Simulated Throughput	Official Throughput	Difference (Percent Error)
	Bn Yen	Bn Yen	TEU	TEU	%
2011	12,036	289,904	17,624,485	17,503,465	0.69
2012	12,072	294,832	17,891,774	17,519,810	2.12
2013	12,193	291,933	17,761,715	17,744,935	0.09
2014	12,012	297,152	18,002,747	17,924,296	0.44
2015	11,795	296,862	17,945,874	17,285,182	3.82

The difference (Percent Error) in Table 5.6 and Table 5.7 was not so big and indicated that both coefficients in 2005 and in 2011 were acceptable. This simulation supported our methodology's application under different economic structure since macroeconomic structure used in Stage I was different from the same used in Stage II.

Furthermore, we made another simulation for container throughput in Stage I by use of conversion coefficients both in 2005 and 2011 which was shown in Table 5.8 while another same simulation was made in Table 5.9 for Stage II. What this study wanted to discuss in this simulation was the simulation accuracy by different coefficients in the same stage as well as same economic structure. If coefficient had higher accuracy or lower percent error in the same economic structure, it certainly meant this coefficient was better choice for this stage.

Table 5.8 Simulated International Container Throughput in Stage I

Year	x_a	x_m	By conversion coefficients in 2005 $l_a = (2.22E-07)$ and $l_m = (4.92E-08)$			By conversion coefficients in 2011 $l_a = (1.92E-07)$ and $l_m = (5.28E-08)$		
			Simulated Throughput	Official Throughput	Percent Error	Simulated Throughput	Official Throughput	Percent Error
	Bn Yen	Bn Yen	TEU	TEU	%	TEU	TEU	%
2005	12,493	304,400	17,730,510	15,732,277	12.70	18,478,033	15,732,277	17.45
2006	12,265	314,836	18,192,830	16,616,471	9.49	18,985,515	16,616,471	14.26
2007	12,542	327,882	18,895,403	17,138,769	10.25	19,727,813	17,138,769	15.11
2008	12,650	322,084	18,634,403	17,129,122	8.79	19,442,281	17,129,122	13.50
2009	12,433	267,582	15,907,451	14,744,605	7.89	16,521,426	14,744,605	12.05
2010	12,253	297,152	17,320,911	16,847,612	2.81	18,048,950	16,847,612	7.13
MAPE					8.65			13.25

1. Mean absolute percent error (MAPE) by coefficient in 2005 was 8.65%.
2. Mean absolute percent error (MAPE) by coefficient in 2011 was 13.25%.

Table 5.9 Simulated International Container Throughput in Stage II

Year	x_a	x_m	By conversion coefficients in 2005 $l_a = (2.22E-07)$ and $l_m = (4.92E-08)$			By conversion coefficients in 2011 $l_a = (1.92E-07)$ and $l_m = (5.28E-08)$		
			Simulated Throughput	Official Throughput	Percent Error	Simulated Throughput	Official Throughput	Percent Error
	Bn Yen	Bn Yen	TEU	TEU	%	TEU	TEU	%
2011	12,036	289,904	16,916,649	17,503,465	-3.35	17,624,485	17,503,465	0.69
2012	12,072	294,832	17,166,895	17,519,810	-2.01	17,891,774	17,519,810	2.12
2013	12,193	291,933	17,051,072	17,744,935	-3.91	17,761,715	17,744,935	0.09
2014	12,012	297,152	17,267,553	17,924,296	-3.66	18,002,747	17,924,296	0.44
2015	11,795	296,862	17,205,306	17,285,182	-0.46	17,945,874	17,285,182	3.82
MAPE					2.68			1.43

3. Mean absolute percent error (MAPE) by coefficient in 2005 was 2.68%.
4. Mean absolute percent error (MAPE) by coefficient in 2011 was 1.43%.

Table 5.8 and Table 5.9 illustrated simulation process by conversion coefficients both in 2005 and 2011. Commonly used mean absolute percent error (MAPE) was chosen as indicator to compare the simulation accuracy in two stages. The simulation result was concluded into Table 5.10.

Table 5.10 MAPE in Stage I and Stage II by Coefficients in 2005 and 2011

Stage	By Coefficients in 2005	By Coefficients in 2011
Stage I	8.65%	13.25%
Stage II	2.68%	1.43%

In the first row of Table 5.10, MAPE by coefficients in 2005 (shadow cell) was lower than the same by coefficients in 2011. The second row also indicated MAPE by coefficients in 2011 (shadow cell) was lower than the same by coefficients in 2005 in the same Stage II. As we mentioned before, it meant the coefficients in 2005 was better for Stage I than the coefficients in 2011 while the coefficients in 2011 was better for Stage II than the coefficients in 2005 compared with official throughput data. Briefly, in row wise, the coefficients estimated by statistical data of Stage I and Stage II were better choice and suitable in this study.

The by-product of Table 5.10 was the comparison in column wise between same coefficients' simulation accuracy in the different stages. For example, MAPE by coefficients in 2005 in Stage I was 8.65% which was higher than the MAPE 2.68% by the same coefficients in Stage II. However, it only indicated the economic structure was different in Stage I and Stage II while it did not mean the coefficients in 2005 were better for Stage II since it was difficult to make comparison against numerical MAPE only in different economic background. Meanwhile, much lower MAPE 1.43% by coefficients in 2011 was found in the same Stage II which certainly indicated that coefficients in 2011 was better choice than coefficients in 2005 for Stage II's container throughput simulation since the same economic structure was deployed.

The only information given in column wise was different economic structure had substantial influence on container throughput. The different MAPE by the same coefficient in column wise only indicated economic structure were different in two stages.

Combined with row and column wise, the simulation above just supported coefficients in 2005 were suitable for Stage I while coefficients in 2011 were better choice for Stage II which was just in line with our study. This empirical analysis also reminded us that different economic structure would have different coefficients while conversion coefficients could only be discussed under the same economic structure. Same conversion coefficients' influence in different economic structure could not be compared against indicator's numerical amount only since economic background was different. This was another qualitative analysis in the container throughput structural study.

5.6 Input-Output Analysis on Container Throughput

After function (5.4) and (5.5) was supported by above empirical analysis, the relationship between industries development and its influence on international container throughput was further explored. The coefficients of $l_{\mathrm{a}} = (1.92\mathrm{E}-07)$ and $l_{\mathrm{m}} = (5.28\mathrm{E}-08)$ was used in below simulation.

By use of Leontief inverse matrix in equation (2.13), equation (3.14) was developed into equation (5.6) to explore inter-relation between industries and international container throughput.

$$IC = L_{ic} \cdot X = L_{ic} \cdot (I - (I - \widehat{\mathrm{M}}) \cdot A)^{-1} \cdot Y \tag{5.6}$$

$L_{ic} = [1.92\mathrm{E}-07 \quad 0 \quad 5.28\mathrm{E}-08 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0]$
$(I - (I - \widehat{\mathrm{M}}) \cdot A)^{-1}$: Leontief inverse matrix
Y: final demand matrix

Since Leontief inverse matrix $(I - (I - \widehat{\mathrm{M}}) \cdot A)^{-1}$ could be found as Appendix 7 from Japanese government, it was possible to calculate international container throughput generated by final demand of every industry.

First of all, it was supposed that every industry's final demand fluctuated by 1 billion Japanese Yen individually in 2011, the relevant container throughput generated was marked in the Column 1 "Container Throughput (TEU/Billion Yen)" in Table 5.11.

For example, final demand of Agriculture industry was supposed to be 1 billion Japanese Yen, thus international container throughput amount generated by this final demand was calculated by use of equation (5.6). The result 234.64 TEU was marked in the top of Column 1 in Table 5.11.

Calculation in equation (5.7) (in Page 64) illustrated example in which Service industry's final demand increased by 1 billion Yen and generated container throughput was 14.04 TEU. Figure 5.1 (in Page 64) just illustrated calculation process by use of Excel file.

The Column 1 in Table 5.11 indicated how many container throughputs were generated by different industries' unit final demand (in 1 billion Japanese Yen). It was logical that both Agriculture and Manufacturing industry would generate container throughput more than other industries. And since agricultural product was always cheaper than processed industrial products, especially much cheaper than electrical appliance or digit-controlled machine, it was obvious that the same value will generate more container throughput in Agriculture industry than Manufacturing industry.

The data in Column 2 in Table 5.11 was adopted from Figure 2.3 released by Japanese government and indicated 13 industries' final demand in 2011 in Japan. And international container throughput was calculated by equation (5.6) with conversion coefficient matrix, Leontief inverse matrix and final demand matrix together. The result was marked in most right Column 3 "Container Throughput (TEU)" in Table 5.11. Figure 5.2 illustrated calculation process of gross amount of international container throughput. The result was same as the amount after data in Column 1 multiplied the same in Column 2.

Table 5.11 Simulated Container Throughput Generated by Various Industries in 2011

No.	Industry	Column 1	Column 2	Column 3
		Container Throughput (TEU/Billion Yen)	Final Demand (Million Yen)	Container Throughput (TEU)
1	Agriculture, forestry and fishery	234.64	3,917,765	919,258
2	Mining	12.96	-23,200	-301
3	Manufacturing	95.05	144,679,538	13,752,331
4	Construction	24.76	42,741,258	1,058,450
5	Electricity, gas and water supply	12.11	7,983,699	96,686
6	Commerce	5.67	59,289,682	336,257
7	Financial & Insurance	5.69	16,396,548	93,425
8	Real Estate	2.42	59,287,615	143,385
9	Transport & postal Service	15.89	20,589,504	327,210
10	Information and communications	8.60	21,415,801	184,192
11	Public administration	8.33	38,268,628	318,802
12	Services	14.04	145,493,938	2,043,002
13	Activities not elsewhere classified	12.17	22,557	275
	Total			19,272,972

Remark: official container throughput is 17,503,465 TEU with percent error 10.11%.

The percent error was 10.11% which could be accepted compared with officially announced statistics in 2011. From above empirical analysis, Agriculture and Manufacturing industries were identified to have remarkable influence on container throughput. Basically, it is in line with common sense that physical industries closely connect with container transport. Meanwhile, above empirical analysis evidently supported that not only physical industries but also non-physical industries generated container throughput though their influence was comparative lower than physical industries.

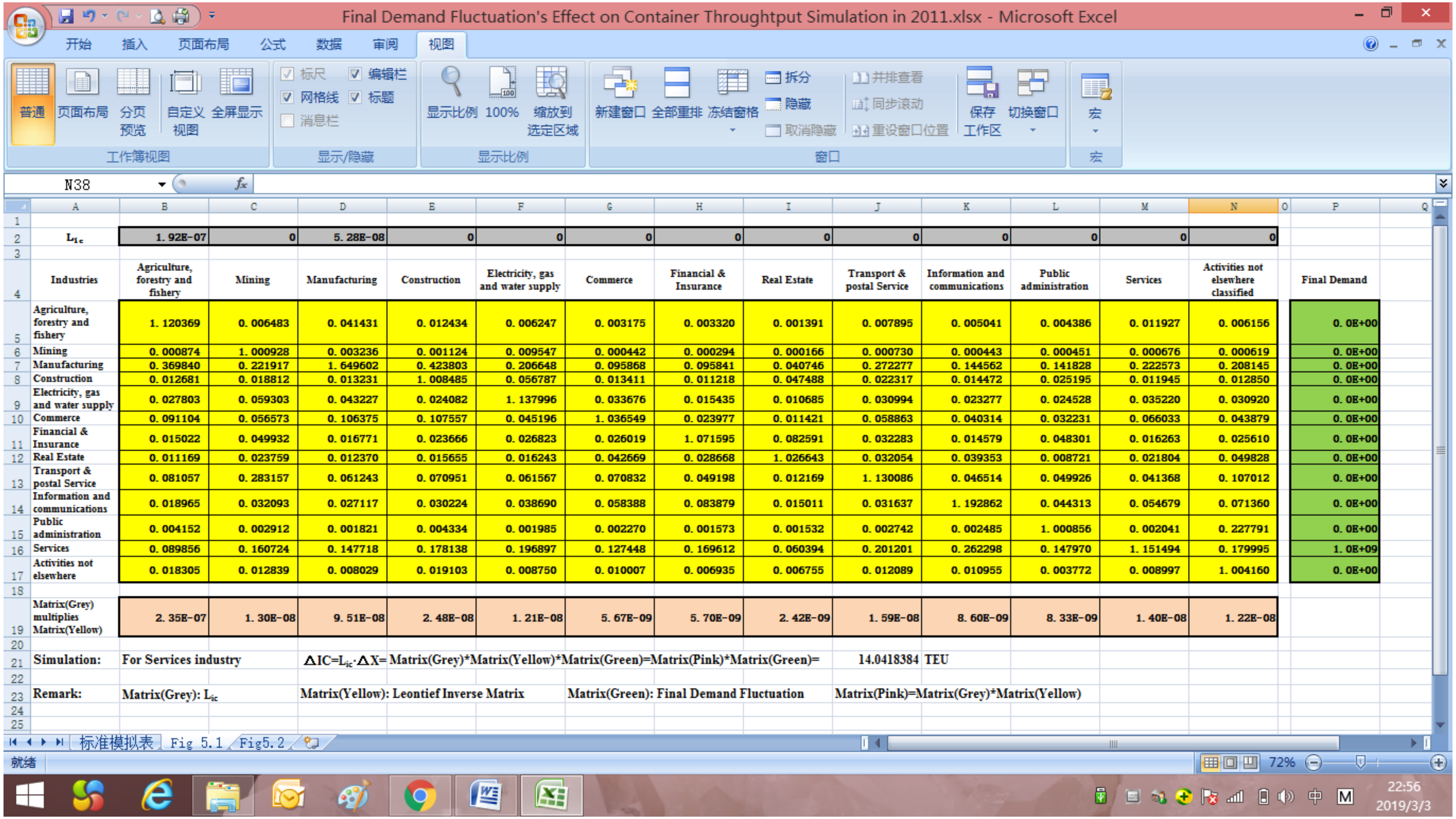
This outcome also helped us to understand why developed countries did not produce so many cargoes but still had huge amount container throughput. Due to their well-developed service industries, developed countries are possible to generate more container throughput than developing countries where the commodities are processed.

Input-output structural analysis provided us an efficient tool to connect various industries with container throughput. Above empirical analysis was only made by 13 industries, if there is 37 or 108 industries, it requires larger amount of calculation.

$$IC = L_{ic} \cdot X = L_{ic} \cdot (I - (I - \widehat{\mathrm{M}}) \cdot A)^{-1} \cdot Y = [1.92\mathrm{E}-07 \quad 0 \quad 5.28\mathrm{E}-08 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0] \cdot$$

$$\begin{pmatrix} 1.120369 & 0.006483 & 0.041431 & 0.012434 & 0.006247 & 0.003175 & 0.003320 & 0.001391 & 0.007895 & 0.005041 & 0.004386 & 0.011927 & 0.006156 \\ 0.000874 & 1.000928 & 0.003236 & 0.001124 & 0.009547 & 0.000442 & 0.000294 & 0.000166 & 0.000730 & 0.000443 & 0.000451 & 0.000676 & 0.000619 \\ 0.369840 & 0.221917 & 1.649602 & 0.423803 & 0.206648 & 0.095868 & 0.095841 & 0.040746 & 0.272277 & 0.144562 & 0.141828 & 0.222573 & 0.208145 \\ 0.012681 & 0.018812 & 0.013231 & 1.008485 & 0.056787 & 0.013411 & 0.011218 & 0.047488 & 0.022317 & 0.014472 & 0.025195 & 0.011945 & 0.012850 \\ 0.027803 & 0.059303 & 0.043227 & 0.024082 & 1.137996 & 0.033676 & 0.015435 & 0.010685 & 0.030994 & 0.023277 & 0.024528 & 0.035220 & 0.030920 \\ 0.091104 & 0.056573 & 0.106375 & 0.107557 & 0.045196 & 1.036549 & 0.023977 & 0.011421 & 0.058863 & 0.040314 & 0.032231 & 0.066033 & 0.043879 \\ 0.015022 & 0.049932 & 0.016771 & 0.023666 & 0.026823 & 0.026019 & 1.071595 & 0.082591 & 0.032283 & 0.014579 & 0.048301 & 0.016263 & 0.025610 \\ 0.011169 & 0.023759 & 0.012370 & 0.015655 & 0.016243 & 0.042669 & 0.028668 & 1.026643 & 0.032054 & 0.039353 & 0.008721 & 0.021804 & 0.049828 \\ 0.081057 & 0.283157 & 0.061243 & 0.070951 & 0.061567 & 0.070832 & 0.049198 & 0.012169 & 1.130086 & 0.046514 & 0.049926 & 0.041368 & 0.107012 \\ 0.018965 & 0.032093 & 0.027117 & 0.030224 & 0.038690 & 0.058388 & 0.083879 & 0.015011 & 0.031637 & 1.192862 & 0.044313 & 0.054679 & 0.071360 \\ 0.004152 & 0.002912 & 0.001821 & 0.004334 & 0.001985 & 0.002270 & 0.001573 & 0.001532 & 0.002742 & 0.002485 & 1.000856 & 0.002041 & 0.227791 \\ 0.809856 & 0.160724 & 0.147718 & 0.178138 & 0.196897 & 0.127448 & 0.169612 & 0.060394 & 0.201201 & 0.262298 & 0.147970 & 1.151494 & 0.179995 \\ 0.018305 & 0.012839 & 0.008029 & 0.019103 & 0.008750 & 0.010007 & 0.006935 & 0.006755 & 0.012089 & 0.010955 & 0.003772 & 0.008997 & 1.004160 \end{pmatrix}$$

$$\cdot \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ (1\mathrm{E}+09) \\ 0 \end{bmatrix} = 14.04(\mathrm{TEU}) \tag{5.7}$$



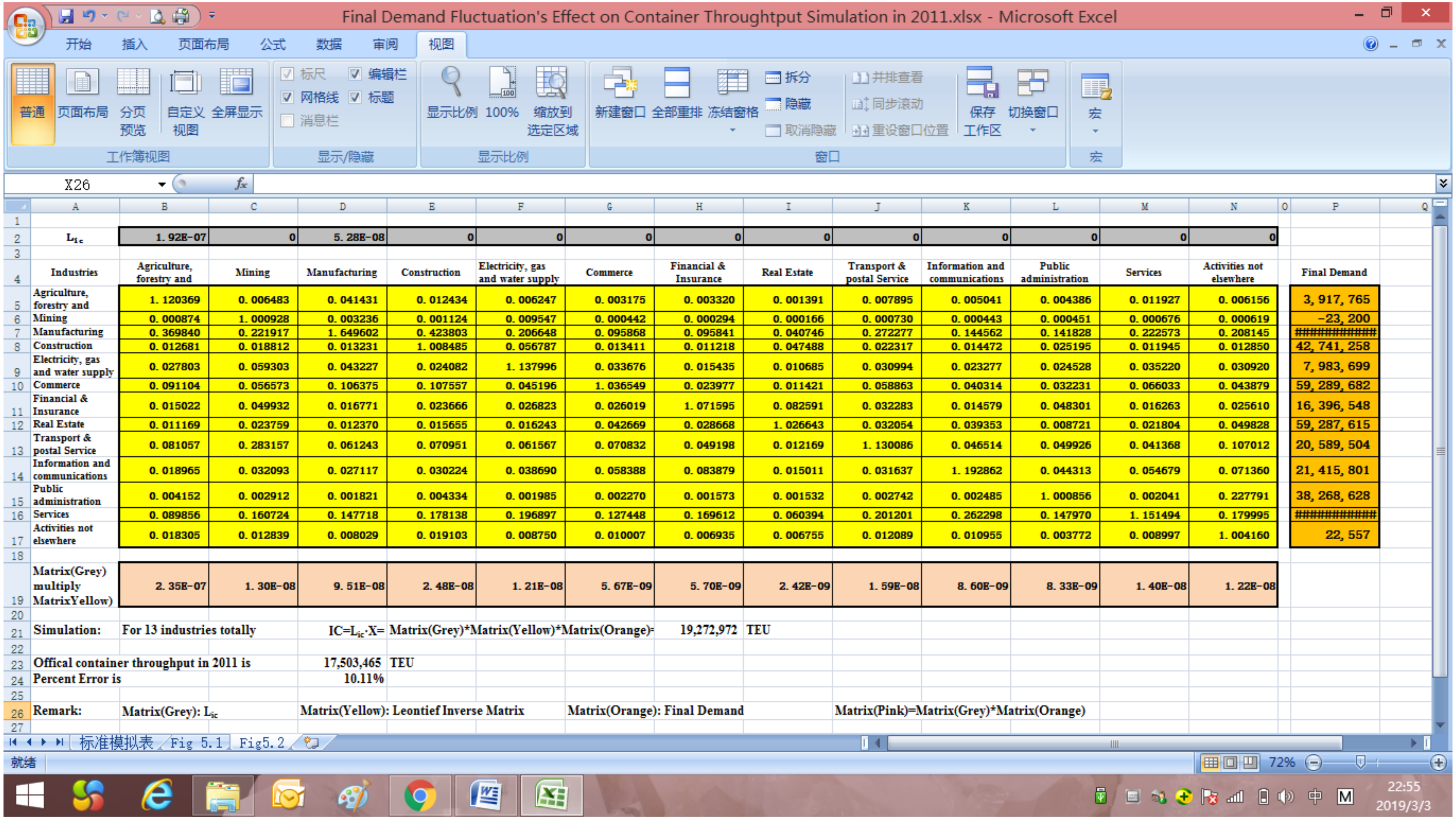
Final Demand Fluctuation's Effect on Container Throughtput Simulation in 2011.xlsx - Microsoft Excel

L_{ic}	1.92E-07	0	5.28E-08	0	0	0	0	0	0	0	0	0	0	
Industries	Agriculture, forestry and fishery	Mining	Manufacturing	Construction	Electricity, gas and water supply	Commerce	Financial & Insurance	Real Estate	Transport & postal Service	Information and communications	Public administration	Services	Activities not elsewhere classified	Final Demand
Agriculture, forestry and fishery	1.120369	0.006483	0.041431	0.012434	0.006247	0.003175	0.003320	0.001391	0.007895	0.005041	0.004386	0.011927	0.006156	0.0E+00
Mining	0.000874	1.000928	0.003236	0.001124	0.009547	0.000442	0.000294	0.000166	0.000730	0.000443	0.000451	0.000676	0.000619	0.0E+00
Manufacturing	0.369840	0.221917	1.649602	0.423803	0.206648	0.095868	0.095841	0.040746	0.272277	0.144562	0.141828	0.222573	0.208145	0.0E+00
Construction	0.012681	0.018812	0.013231	1.008485	0.056787	0.013411	0.011218	0.047488	0.022317	0.014472	0.025195	0.011945	0.012850	0.0E+00
Electricity, gas and water supply	0.027803	0.059303	0.043227	0.024082	1.137996	0.033676	0.015435	0.010685	0.030994	0.023277	0.024528	0.035220	0.030920	0.0E+00
Commerce	0.091104	0.056573	0.106375	0.107557	0.045196	1.036549	0.023977	0.011421	0.058863	0.040314	0.032231	0.066033	0.043879	0.0E+00
Financial & Insurance	0.015022	0.049932	0.016771	0.023666	0.026823	0.026019	1.071595	0.082591	0.032283	0.014579	0.048301	0.016263	0.025610	0.0E+00
Real Estate	0.011169	0.023759	0.012370	0.015655	0.016243	0.042669	0.028668	1.026643	0.032054	0.039353	0.008721	0.021804	0.049828	0.0E+00
Transport & postal Service	0.081057	0.283157	0.061243	0.070951	0.061567	0.070832	0.049198	0.012169	1.130086	0.046514	0.049926	0.041368	0.107012	0.0E+00
Information and communications	0.018965	0.032093	0.027117	0.030224	0.038690	0.058388	0.083879	0.015011	0.031637	1.192862	0.044313	0.054679	0.071360	0.0E+00
Public administration	0.004152	0.002912	0.001821	0.004334	0.001985	0.002270	0.001573	0.001532	0.002742	0.002485	1.000856	0.002041	0.227791	0.0E+00
Services	0.089856	0.160724	0.147718	0.178138	0.196897	0.127448	0.169612	0.060394	0.201201	0.262298	0.147970	1.151494	0.179995	1.0E+09
Activities not elsewhere	0.018305	0.012839	0.008029	0.019103	0.008750	0.010007	0.006935	0.006755	0.012089	0.010955	0.003772	0.008997	1.004160	0.0E+00
Matrix(Grey) multiplies Matrix(Yellow)	2.35E-07	1.30E-08	9.51E-08	2.48E-08	1.21E-08	5.67E-09	5.70E-09	2.42E-09	1.59E-08	8.60E-09	8.33E-09	1.40E-08	1.22E-08	

Simulation: For Services industry $\Delta IC = L_{ic} \cdot \Delta X =$ Matrix(Grey)*Matrix(Yellow)*Matrix(Green)=Matrix(Pink)*Matrix(Green)= 14.0418384 TEU

Remark: Matrix(Grey): L_{ic} Matrix(Yellow): Leontief Inverse Matrix Matrix(Green): Final Demand Fluctuation Matrix(Pink)=Matrix(Grey)*Matrix(Yellow)

Fig 5.1 Japanese International Container Throughput Simulation (by Services industry final demand 1 billion yen increasing in 2011)



Industries	Agriculture, forestry and	Mining	Manufacturing	Construction	Electricity, gas and water supply	Commerce	Financial & Insurance	Real Estate	Transport & postal Service	Information and communications	Public administration	Services	Activities not elsewhere	Final Demand
L_{ic}	1.92E-07	0	5.28E-08	0	0	0	0	0	0	0	0	0	0	
Agriculture, forestry and	1.120369	0.006483	0.041431	0.012434	0.006247	0.003175	0.003320	0.001391	0.007895	0.005041	0.004386	0.011927	0.006156	3,917,765
Mining	0.000874	1.000928	0.003236	0.001124	0.009547	0.000442	0.000294	0.000166	0.000730	0.000443	0.000451	0.000676	0.000619	-23,200
Manufacturing	0.369840	0.221917	1.649602	0.423803	0.206648	0.095868	0.095841	0.040746	0.272277	0.144562	0.141828	0.222573	0.208145	############
Construction	0.012681	0.018812	0.013231	1.008485	0.056787	0.013411	0.011218	0.047488	0.022317	0.014472	0.025195	0.011945	0.012850	42,741,258
Electricity, gas and water supply	0.027803	0.059303	0.043227	0.024082	1.137996	0.033676	0.015435	0.010685	0.030994	0.023277	0.024528	0.035220	0.030920	7,983,699
Commerce	0.091104	0.056573	0.106375	0.107557	0.045196	1.036549	0.023977	0.011421	0.058863	0.040314	0.032231	0.066033	0.043879	59,289,682
Financial & Insurance	0.015022	0.049932	0.016771	0.023666	0.026823	0.026019	1.071595	0.082591	0.032283	0.014579	0.048301	0.016263	0.025610	16,396,548
Real Estate	0.011169	0.023759	0.012370	0.015655	0.016243	0.042669	0.028668	1.026643	0.032054	0.039353	0.008721	0.021804	0.049828	59,287,615
Transport & postal Service	0.081057	0.283157	0.061243	0.070951	0.061567	0.070832	0.049198	0.012169	1.130086	0.046514	0.049926	0.041368	0.107012	20,589,504
Information and communications	0.018965	0.032093	0.027117	0.030224	0.038690	0.058388	0.083879	0.015011	0.031637	1.192862	0.044313	0.054679	0.071360	21,415,801
Public administration	0.004152	0.002912	0.001821	0.004334	0.001985	0.002270	0.001573	0.001532	0.002742	0.002485	1.000856	0.002041	0.227791	38,268,628
Services	0.089856	0.160724	0.147718	0.178138	0.196897	0.127448	0.169612	0.060394	0.201201	0.262298	0.147970	1.151494	0.179995	############
Activities not elsewhere	0.018305	0.012839	0.008029	0.019103	0.008750	0.010007	0.006935	0.006755	0.012089	0.010955	0.003772	0.008997	1.004160	22,557
Matrix(Grey) multiply MatrixYellow)	2.35E-07	1.30E-08	9.51E-08	2.48E-08	1.21E-08	5.67E-09	5.70E-09	2.42E-09	1.59E-08	8.60E-09	8.33E-09	1.40E-08	1.22E-08	

Simulation: For 13 industries totally IC=L_{ic}·X= Matrix(Grey)*Matrix(Yellow)*Matrix(Orange)= 19,272,972 TEU

Offical container throughput in 2011 is 17,503,465 TEU

Percent Error is 10.11%

Remark: Matrix(Grey): L_{ic} Matrix(Yellow): Leontief Inverse Matrix Matrix(Orange): Final Demand Matrix(Pink)=Matrix(Grey)*Matrix(Orange)

Fig 5.2 Japanese International Container Throughput Simulation (by all industries' final demand in 2011)

Part 6 Conclusion

Compared with bulk or tanker transport, container transport is still a young business and has only experienced thirty year's rapid development from 1990s. It was just from year of 2008 that UNCTAD began to release national container throughput data while she has released seaborne trade data for many decades.

However, container transport management, including routing selection, equipment balance, service network optimization and information system development has been much more complicated than any other transport modes' management. For the researches on container transport as well as container throughput, a lot of interesting topics are still worth studying.

Government officials make studies on container throughput to make full of use of limited coastline and land resource while pursuing container handling balance between supply and demand. Private investors make same studies to catch the revenue scale and pursue the investment efficiency.

This study firstly raised question on GDP data as a suitable variable to explain container throughput in regression analysis. Qualitative conflict was found after examining economic facts behind GDP data and container throughput by use of GDP expenditure approach. Further empirical analysis evidently indicated that though GDP data was correlated with container throughput in some specific cases, it was just a correlation and could not explain container throughput volatility in causality.

Meanwhile, we found that most past research focused on aggregate container throughput, for example, national gross container throughput or regional international container throughput. However, there was no structural analysis on relationship between container throughput and various industries in macroeconomic system.

In order to improve container throughput analysis, this study re-organized aggregate analysis methodology to match the economic facts behind variables as much as possible while proposing structural analysis methodology to demonstrate the connection between various industries and container throughput

6.1 Methodology Summary

Though aggregate and structural analyses are different approaches to container throughput studies, they still have some common points as well as unique aspects at the same time.

6.1.1 Common Points

First of all, this study distinguished business model with statistical model and adopted container throughput generation mechanism in function (2.15). Both aggregate and structural analysis in this study followed this mechanism to make further analysis after decomposing container throughput into three simple systems including domestic, international and international transshipment throughput segments. And in each simple system, it is possible to match economic theory with model as much as possible in consideration of economic facts behind variables.

Secondly, this study identified that international transshipment container throughput did not correlate with hub's local economy. Transshipment volume was firstly removed before aggregate regression analysis was made with macro data series.

Thirdly, this study selected independent variables in causality with container throughput segments and strongly proposed to adopt macro data series in real term or process the same with deflator. We believed selection of independent variables and data process was as important as statistical modeling in regression analysis.

6.1.2 Aggregate Analysis

Besides above common points, this study proposed evaluation of industry structure, trade structure and transport structure to qualitatively describe the economic background when aggregate regression analysis was made.

After that, integrated analysis combined by both quantitative and qualitative analysis was strongly proposed to confirm exact causality between variables. Both quantitative and qualitative analysis had mutual reinforced function and helped us to minimize nonsense regression in container throughput analysis.

In line with above methodology, this study made empirical analysis by use of macro indicators selected from GDP expenditure approach. Domestic demand corresponded to domestic container throughput segment while international merchandise trade corresponded to international container throughput segment. Data series from Japan, China, Korea and Hong Kong SAR were collected to verify new methodology.

Table 6.1 concluded comparison between past methodology and new methodology for aggregate analysis.

Table 6.1 Conclusion of Aggregate Analysis Methodology

Item	GDP-based Methodology	Proposed Methodology
Kind of system	Simple system	Complex system
Business model	None	CONT=DC+IC+TC
Independent variable	GDP	DC: $X_{11}, X_{12}, \ldots, X_{1n}$ IC: $X_{21}, X_{22}, \ldots, X_{2n}$ TC: $X_{31}, X_{32}, \ldots, X_{3n}$
Causality with container throughput generation mechanism	Partially conflict	Yes
Statistical model	CONT=f(GDP)	DC=$f_1(X_{11}, X_{12}, \ldots, X_{1n})$ IC=$f_2(X_{21}, X_{22}, \ldots, X_{2n})$ TC=$f_3(X_{31}, X_{32}, \ldots, X_{3n})$
Deflator processing	No	Yes
Transshipment identification	No	Yes
Consistent theory and model	No	Yes
Consistent model and data	Partially	Partially
Structure evaluation	No	Yes
Integrated analysis	No	Yes

Evidently, empirical analysis strongly supported new methodology. First of all, Japan and Hong Kong cases identified nominal GDP was not a suitable variable for container throughput analysis and strongly supported the result of qualitative analysis. Secondly, the correlation between domestic demand and domestic container throughput was confirmed, and so was the correlation between international merchandise trade volume and international container throughput in expenditure frame. Thirdly, new independent variable “gross demand” created in Part 3 was successfully verified in the linear regression model for positive correlation with the gateway container throughput. Fourthly, the removal of transshipment volume and employment of deflator enhanced the correlation between macro indices and container throughput. Finally, empirical analysis confirmed structure evaluation’s contribution to explain the correlation analysis outcome, especially for Hong Kong case. Hong Kong underwent industry, trade and transport structure change sharply within last two decades so that gateway, domestic and international container throughput could not be explained by selected macro indicators. The quantitative and qualitative analysis mutually reinforced each other.

In brief, group of domestic demand and international merchandise trade can be applicable to gateway container throughput analysis. Similar to traditional GDP Model, expenditure frame created in this study did not realize the trinity of theory, model and data. But the content was different. Traditional GDP Model did not realize the consistency between theory and model while expenditure frame realized consistency between theory and model but could not realize complete matching between model and data due to limited data source. Thus, economic structure evaluation was necessary as a complement to recognize the consistent degree between model and data.

6.1.3 Structural Analysis

Structural analysis enables us to understand the inter-relationship among industries and interactive mechanism within macroeconomic system. This study firstly proposed input-output analysis to explain the mechanism between various industries and container throughput. Leontief inverse matrix was used to establish function between container throughput segments and industries’ final demand after conversion coefficients were calculated by trade statistics. The empirical analysis was made by use of Japanese international container throughput and macroeconomic data from 2005 and 2011 Input-Output Table. Especially this study connected non-physical industries with container traffic to explain the mechanism between tertiary industries and container throughput. The outcome of empirical analysis was quite logic and consistent with common sense.

Two empirical analyses evidently supported proposed methodologies and mutually supported with each other. Both aggregate and structural analyses were consistent after same generation mechanism and data source from SNA were adopted.

Firstly, aggregate analysis illustrated gross container throughput trend while structural analysis identified the key industries which heavily influenced container throughput and made additional explanation to aggregate analysis. Secondly, the key industries identified by structural analysis was logic and in line with common sense. Thirdly, structural analysis which identified agriculture and manufacturing industry generated most container throughput was additional explanation and consistent with industry structure evaluation in aggregate analysis.

6.2 Study Review

Though container transport is still a young business compared with conventional transport, more and more researches have been and are being made on container throughput with the rapid development of container transport since thirty years before. International organization, academic institutes, broker agencies and consultant companies published more and more data, papers and analysis reports on container throughput. For example, UNCTAD has begun to release countries' container throughput data since year of 2008 after World Bank had released same historic data. This also reflects the great contribution of container transport to world economy. The literatures in Part 2 are just a small part of whole researches and container transport still has a lot of issues worth studying.

6.2.1 Comparison with Frontier Studies

For aggregate analysis, RWI/ISL Container Throughput Index is a successful try and unique index for container throughput found in shipping field. This index has been released since 2012 by two famous Germany institutes. Compared with our methodology study, several common points were found with several differences at the same time.

For common points, firstly, the economic theory and mechanism used in both studies are same as global economy is the key driving force for all throughput activities. Secondly the indicators used in correlation analysis were same as this study for IC, namely international merchandise trade data and international container throughput. Thirdly, both processed data with deflator to secure the real term macro indicators. Fourthly, both studies only indicated high correlation between trade and container throughput data and did not discuss the statistical model for further forecasting. Linear regression analysis used in both studies was not the target of studies and just an evidence to indicate the feasibility to make further econometric analysis.

However, this study's scope was bigger than RWI/ISL Index as domestic throughput was additionally discussed. Meanwhile, the treatment of transshipment segment was different(13). Though RWI/ISL recognized influence of transshipment business, they did not remove transshipment data before correlation analysis was made. In this study, transshipment data was removed before correlation analysis was made to match the economic facts as much as possible.

In general, the methodology used in IC study was similar but this study considered and analyzed domestic throughput together while removal of transshipment segment made business model more consistent with economic theory for further study.

6.2.2 Contribution

After questioning GDP as a suitable independent variable for container throughput regression analysis, this study started the research from generation mechanism to make study on relationship between macro economy and container throughput by re-organizing aggregate analysis methodology and firstly proposing input-output analysis for structural analysis. Empirical analysis evidently supported proposed methodology and further demonstrated container throughput generation mechanism.

Besides container throughput could be divided into three segments including domestic, international and international transshipment throughput, new demonstration raised at least two additional points. The first point was container throughput was closely connected macro economy. Though GDP was questioned as suitable independent variable, this study still used a lot of macro indicators from SNA. Domestic demand and international merchandise trade were empirically supported as suitable independent variables for container throughput segment regression analysis. The second point was different economic structure had different driving force on container throughput. Particularly domestic industry structure had great influence on container throughput. Both structure evaluation in aggregate analysis and structural analysis supported this fact.

Compared with pure statistic model, this study emphasized trinity of economic theory, statistic model and accessible data while strongly proposing integrated analysis for complex system of container transport. On the one hand, this study firstly adopted integrated analysis in aggregate regression analysis by quantitative analysis and qualitative structure evaluation at the same time. Structure evaluation quite supported correlation analysis in empirical analysis. On the other hand, this study firstly made input-output analysis and integrated structural analysis with aggregate analysis together. Structural analysis indicated industry structure had great influence on container throughput and reinforced with structure evaluation in aggregate analysis.

The identification of container throughput complex system and introduction of integrated analysis fundamentally improved methodology of container throughput analysis. Combined with aggregate and structural analysis, government officials can work out industry policy to meet the target of gateway container throughput.

This study never intends to overthrow GDP's dominant position in daily economic life including its core position in national account system. This study still made use of GDP conception when most data used in this study were picked up from GDP statistic system. SNA is a big treasure and the problem is just our superficial understanding. Definitely GDP data itself was not an explanatory variable for gateway container throughput regression analysis while SNA and its macroeconomic database were still foundation of container throughput analysis, both for aggregate and structural analysis.

Since this research focused on methodology, it was independent to statistical models so that this study did not challenge any statistical model and only made correlation analysis and simplest regression analysis. This study made every effort to explain methodology with concise economic facts and the simplest language while trying to provide more statistics materials rather than use complicated mathematic tools. It is expected that this fundamental research will lay a solid foundation for container throughput analysis.

However, there were still several issues where this study was not enough as below:

Firstly, though some discussion on the relationship between container throughput and macroeconomic system was made, the depth of comprehensive understanding of SNA was not enough. SNA, including GDP data series and other macroeconomic mechanisms, exhibited macro economy from many respects but we just made use of very small part of this statistics system. It is necessary to explore more suitable macro indicators and efficient methodologies.

Secondly, empirical analysis data in this analysis were still not enough. We made empirical aggregate analysis by Japan, China, Korea and Hong Kong while structural analysis was made by Japanese input-output table and international container throughput. Though Hong Kong was a good model for international container hub with big share of transshipment and re-export business, Japan, China and Korea were strong in manufacturing industries and heavily relied on export industry. Meanwhile, how to ensure data accessibility for domestic container trade was another topic for input-output structural analysis. If possible, more empirical data should be collected to verify new methodology under different scenarios.

Thirdly, economic structure evaluation was firstly proposed in this study but it was still in the qualitative stage. The content and criterion of structure evaluation were still obscure and decided by researcher's experience. More studies should be made on the content of structure evaluation and its criterion.

6.3 Research Prospect

OECD (2012) undertook researches on "Strategic Transport Infrastructure Needs to 2030" and pointed out over the long term, world GDP was expected to grow strongly and could in fact double over the period to 2030. With global GDP doubling by 2030, maritime container traffic could increase by more than 6% annually and it is estimated port handing of maritime containers worldwide could quadruple by 2030.

The Infrastructure to 2030 report concluded that global port infrastructure facilities capital expenditure would be aggregately USD 630 billion from 2015 to 2030. Improved funding and financing arrangements will be needed in many countries, given their current deficit and debt levels and other expected demands on budget resources.

On July 15th 2014, the group of emerging economies BRICS signed the long-anticipated document in Brazil to create the $100 billion New Development Bank (NDB), and a reserve currency pool worth over another $100 billion. The bank's primary focus of lending will be infrastructure projects with authorized lending of up to $34 billion annually.

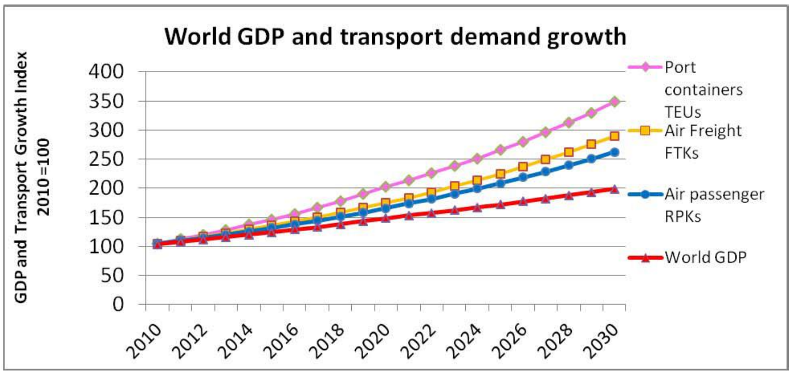


Fig 6.1 World GDP and Transport Demand Growth

On May 20th-22nd 2015, the 5th Chief Negotiators' Meeting on Establishing the Asian Infrastructure Investment Bank (AIIB) was held in Singapore. The Meeting concluded discussions and finalized the Articles of Agreement (AOA) for the AIIB. It is expected that the AOA would be ready for signing by the end of June and the AIIB would be operational by the end of this year with another $100 billion capital.

In the meantime, Japanese government announced to invest third $100 billion to Asian infrastructure within next five years while Chinese government was strongly promoting maritime silk-road construction.

Japanese researcher Nagano Hiromichi (2004) made study by use of GDP per capita and found container volume per head would decrease with the increase of GDP per capita in major developed countries. This study followed his methodology and collected latest data shown in Table 6.2 by use of data in year of 2010 from IMF and UNCTAD.

Table 6.2 GDP per capita and Population per TEU

Country	Population	Container Throughput	GDP per capita	Population per TEU
	Million Persons	Million TEU	USD	Persons/TEU
China	1,341	130	4,478	10.3
Taiwan	23.2	12.7	19,261	1.8
Phillipines	92.6	4.95	2,155	18.7
Malaysia	28.6	18.27	8,920	1.6
Indonesia	237.6	8.48	3,178	28.0
Vietnam	86.9	5.98	1,297	14.5
Thailand	67.3	6.65	5,062	10.12
Cambodia	14.4	0.22	781	65.5
Myanmar	49.7	0.19	997	261.6
Bangladesh	151.1	1.36	807	111.1
Sri Lanka	20.4	4	2,428	5.1
Pakistan	169	2.15	1,048	78.6
India	1,195	9.75	1,430	122.6
UAE	8.26	15.18	34,611	0.5
Iran	74.5	2.59	6,230	28.8
Saudi Arabia	27.6	5.3	19,112	5.2
Oman	2.9	3.89	19,698	0.75
Yemen	24.4	0.4	1,267	61
Bahrain	1.235	0.29	20,823	4.25
Syria	21.4	0.65	2807	32.9
Israel	7.6	2.28	30,747	3.3
Lebanon	4.34	0.95	8,755	4.6
Turkey	73.1	5.57	10,001	13.1
Japan	128	18.10	43,095	7.1
United States	309.8	42.33	48,309	7.31
United Kingdom	62.3	8.59	38,594	7.25
France	62.8	5.56	42,249	11.3
Germany	81.7	14.82	41,876	5.51
Italy	59.2	9.79	35,969	6.04
Canada	34	4.83	47,512	7.0
Korea	49.4	18.54	22,151	2.7
Australia	22.2	6.67	56,194	3.3
New Zealand	4.4	2.46	33,227	1.8

Data source: from International Monetary Fund and UNCTAD

In above table, developing countries, especially ASEAN and South Asian countries' population per TEU data is quite higher than developed countries, that means they will have great potential to develop container transport. Several developing countries population per TEU data has reached developed countries' level due to transshipment service, just like Sri Lanka's Colombo is an important hub for the cargo to India while Port Kelang and Tanjung Pelepas are handling huge amount transshipment cargo in Malaysia.

That means an infrastructure construction booming in Asia can be expected with so much national funding and container terminal, as a bridge between developing countries and global trade definitely will be one of the hot sectors in this booming.

Of course, recently world politics and economies are experiencing drastic change. In 2016, GDP growth rate was firstly lower than the trade growth rate. Drewry Shipping Consultants downgraded annual growth rate of global container throughput from 4.5% to 2.7% during 2015 and 2020. It is expected that growth rate of global container throughput in 2016 is about 0.3%. In the east coast of North America, Great China and Oceania, throughput growth is expected to slow further. APMT has sold or partially sold terminal assets in above mentioned areas. The European Court of Audit also released a report that during 2000 and 2013, one-third of EU invested terminal is ineffectively operated while some assets in more than three years did not reach full load operation.

All above changes strengthened the value of this study on container throughput which indicated demand factor of container terminal investment. New methodology was aimed to provide an easy but reliable tool for the asset investors, government policy makers, container terminal management agencies and so on. In the meantime, this methodology is also workable to other transport mode demand analysis including port traffic analysis. Of course, basic economic facts and transport structure review should vary from different research object but the methodology keeps same.

From the practical purpose, every concerned party would like to have more causal analysis in order to secure reliability and certainty; on the other hand, there is not methodology which can absolutely prevent nonsense or false regression since many steps in regression analysis still depend on personal experience and judgment, just like variable selection. This study cannot guarantee any sound regression but wish to avoid false regression as much as possible and combine structural analysis to deepen the studies on container throughput by full use of SNA.

Appendix 1 Macroeconomic Indicators of Japan

Item	Nominal GDP	Real GDP	Deflator	CA Percent of GDP	Nominal X'	Nominal I_m'	Exchange Rate	Nominal X"+I_m"
Unit	Billion Yen	Billion Yen	-	%	Billion USD	Billion USD	USD/Yen	Billion Yen
From	IMF	IMF	IMF	IMF	IMF	IMF	IMF	MOF
2000	509,860	474,847	107.373	2.761	478	380	107.77	37,112
2001	505,543	476,535	106.087	2.072	404	349	121.53	38,158
2002	499,147	477,915	104.443	2.741	417	337	125.39	38,794
2003	498,855	485,968	102.652	3.24	472	383	115.93	40,126
2004	503,725	497,441	101.263	3.91	566	455	108.19	44,464
2005	503,903	503,921	99.996	3.721	595	515	110.22	48,545
2006	506,687	512,452	98.875	4.006	647	579	116.3	54,895
2007	512,975	523,686	97.955	4.87	714	622	117.75	60,482
2008	501,209	518,231	96.715	2.941	782	763	103.36	59,042
2009	471,139	489,588	96.232	2.885	581	552	93.57	
2010	482,384	512,364	94.149	3.961	770	694	87.78	
2011	471,311	510,045	92.406	2.142	823	855	79.81	
2012	475,110	518,989	91.545	0.986	799	886	79.79	
2013	480,128	527,362	91.043	0.684	715	832	97.6	
2014	487,882	527,050	92.557	0.531	690	812	105.94	

Remark:
1. X' denotes export merchandise trade amount.
2. I_m' denotes import merchandise trade amount.
3. X" denotes export merchandise trade amount by maritime container transport mode.
4. I_m" denotes import merchandise trade amount by maritime cntainer transport mode.

Appendix 2 Macroeconomic Indicators of China

Item	Nominal GDP	Real GDP	Deflator	Nominal CA	Nominal X'	Nominal I_m'	Exchange Rate
Unit	Billion CNY	Billion CNY	-	Billion CNY	Billion USD	Billion USD	USD/CNY
From	IMF	IMF	IMF	NBS & IMF	IMF	IMF	IMF
1990	1,935	1,935	100	51	63	54	4.78
1991	2,258	2,113	107	62	72	64	5.32
1992	2,757	2,413	116	28	86	82	5.51
1993	3,694	2,751	133	-68	92	104	5.76
1994	5,022	3,111	161	63	121	116	8.62
1995	6,322	3,451	183	100	149	132	8.35
1996	7,416	3,796	194	146	151	139	8.31
1997	8,166	4,149	198	355	183	142	8.29
1998	8,653	4,473	196	363	184	140	8.28
1999	9,113	4,813	193	254	195	166	8.28
2000	9,875	5,217	197	239	249	225	8.28
2001	10,903	5,650	201	232	267	244	8.28
2002	12,048	6,164	202	309	326	295	8.28
2003	13,661	6,781	208	295	438	413	8.28
2004	16,096	7,466	222	424	594	561	8.28
2005	18,742	8,310	231	1,021	762	660	8.19
2006	22,271	9,363	240	1,665	969	792	7.97
2007	26,660	10,693	259	2,343	1,218	956	7.61
2008	31,597	11,723	279	2,423	1,429	1,132	6.95
2009	34,878	12,803	279	1,504	1,202	1,004	6.83
2010	40,282	14,136	298	1,506	1,578	1,394	6.77
2011	47,262	15,451	322	1,169	1,899	1,741	6.46
2012	52,940	16,650	330	1,464	2,050	1,817	6.31
2013	58,667	17,940	337	1,455	2,211	1,949	6.20
2014	63,761	19,262	340	1,746	2,343	1,963	6.14

Remark: 1. X' denotes export merchandise trade amount.
2. I_m' denotes import merchandise trade amount.

Appendix 3 Macroeconomic Indicators of Korea

Item	Nominal GDP	Real GDP	Deflator	CA Percent of GDP	Nominal X'	Nominal I_m'	Exchange Rate
Unit	Billion KRW	Billion KRW	-	%	Billion USD	Billion USD	USD/KRW
From	IMF	IMF	IMF	IMF	IMF	IMF	IMF
1990	197,712	419,518	47	-1	68	74	708
1991	238,877	462,955	52	-2	72	82	733
1992	273,267	491,544	56	-1	77	83	781
1993	310,074	525,200	59	1	86	87	803
1994	366,054	573,550	64	-1	101	102	803
1995	428,927	628,442	68	-2	131	135	771
1996	481,141	676,169	71	-4	138	150	804
1997	530,347	716,213	74	-2	144	145	951
1998	524,477	677,028	77	11	133	93	1,401
1999	576,873	753,590	77	4	144	120	1,189
2000	635,185	820,844	77	2	172	160	1,131
2001	688,165	857,990	80	1	150	141	1,291
2002	761,939	921,759	83	1	162	152	1,251
2003	810,915	948,796	85	2	194	179	1,192
2004	876,033	995,286	88	4	254	224	1,145
2005	919,797	1,034,338	89	1	284	261	1,024
2006	966,055	1,087,876	89	0	325	309	955
2007	1,043,258	1,147,311	91	1	371	357	929
2008	1,104,492	1,179,771	94	0	422	435	1,102
2009	1,151,708	1,188,118	97	4	364	323	1,277
2010	1,265,308	1,265,308	100	3	466	425	1,156
2011	1,332,681	1,311,893	102	2	555	524	1,108
2012	1,377,457	1,341,966	103	4	548	520	1,126
2013	1,428,295	1,381,838	104	6	560	516	1,095
2014	1,491,585	1,427,656	104	6	573	526	1,053

Remark:
1. X' denotes export merchandise trade amount.
2. I_m' denotes import merchandise trade amount.

Appendix 4 Macroeconomic Indicators of Hong Kong SAR

Item	Nominal GDP	Real GDP	Deflator	Nominal CA	Nominal X'	Nominal I_m'	Exchange Rate
Unit	Million HKD	Million HKD	-	Million HKD	Million HKD	Million HKD	USD/HKD
From	CSD HK	CSD HK	IMF	CSD HK	CSD HK	CSD HK	IMF
1992	779,335	943,516	83	41,600	924,952	958,462	7.74
1993	900,153	1,003,358	90	62,080	1,046,250	1,075,710	7.74
1994	1,022,733	1,072,216	95	21,998	1,170,013	1,254,427	7.73
1995	1,105,461	1,112,884	99	-27,447	1,344,127	1,495,706	7.74
1996	1,229,481	1,168,953	105	20,909	1,397,917	1,539,851	7.73
1997	1,323,862	1,190,138	111	-45,604	1,455,949	1,619,468	7.74
1998	1,259,306	1,118,459	113	13,884	1,347,649	1,432,423	7.75
1999	1,227,658	1,136,910	108	66,295	1,349,000	1,395,521	7.76
2000	1,267,175	1,214,735	104	59,978	1,572,689	1,661,404	7.79
2001	1,299,218	1,267,950	102	58,384	1,480,987	1,549,222	7.80
2002	1,277,314	1,290,477	99	105,936	1,562,121	1,601,527	7.80
2003	1,234,761	1,327,215	93	114,050	1,749,089	1,794,059	7.79
2004	1,291,902	1,440,360	90	114,542	2,027,031	2,099,545	7.79
2005	1,383,049	1,544,288	90	172,215	2,251,744	2,311,091	7.78
2006	1,474,329	1,655,062	89	168,756	2,467,357	2,576,340	7.77
2007	1,650,756	1,796,761	92	176,224	2,698,850	2,852,522	7.80
2008	1,707,487	1,834,982	93	173,712	2,843,998	3,024,089	7.79
2009	1,659,245	1,789,870	93	124,285	2,494,746	2,702,966	7.75
2010	1,777,720	1,912,493	93	96,474	3,061,252	3,395,057	7.77
2011	1,935,195	2,003,785	97	77,051	3,411,364	3,848,200	7.78
2012	2,037,064	2,037,064	100	23,031	3,591,776	4,116,410	7.76
2013	2,125,353	2,089,723	102	18,065	3,816,390	4,394,928	7.76
2014	2,255,635	2,154,091	105	1,039	3,877,458	4,471,810	7.75

Remark:
1. X' denotes export merchandise trade amount.
2. I_m' denotes import merchandise trade amount.
3. CSD HK denotes Census and Statistics Department of Hong Kong SAR Government

Appendix 5 Primary and Secondary Industry Value Added

Year	Real (PRI+SEC)			
	Japan	China	Korea	Hong Kong
	Billion Yen	Billion CNY	Billion KRW	Million HKD
	MOF	NBS	IMF	HK-ADS
1990	-	1,276	194,660	-
1991	-	1,350	215,447	-
1992	-	1,517	221,392	186,941
1993	-	1,755	233,858	172,860
1994	-	1,988	253,587	165,329
1995	-	2,230	277,777	165,986
1996	-	2,454	292,553	167,878
1997	-	2,622	304,442	164,199
1998	-	2,739	281,971	156,459
1999	-	2,877	310,844	155,316
2000	152,958	3,061	348,738	157,959
2001	143,069	3,237	351,376	152,305
2002	137,265	3,472	370,017	140,569
2003	136,686	3,836	380,636	138,758
2004	138,021	4,287	412,971	134,967
2005	136,054	4,763	420,406	133,765
2006	137,312	5,325	433,483	135,399
2007	140,042	5,971	455,702	124,127
2008	133,823	6,554	457,576	128,810
2009	117,314	6,976	466,534	124,161
2010	127,349	7,752	515,497	131,653
2011	120,184	8,479	536,531	135,522
2012	121,153	8,958	543,883	140,541
2013	123,873	9,407	562,217	147,277
2014	127,337	9,878	578,712	153,964

Appendix 6 Container Throughput

Country /Region	Japan			China			
Item	DC	IC	CONT	DC	IC	DF	CONT
Unit	TEU	TEU	TEU	10,000 TEU	10,000 TEU	10,000 TEU	10,000 TEU
From	MLIT	MLIT	MLIT	MOT	MOT	MOT	CPHA & MOT
1990	-	-	-	-	-	-	156
1991	-	-	-	-	-	-	217
1992	-	-	-	-	-	-	277
1993	-	-	-	-	-	-	380
1994	-	-	-	-	-	-	507
1995	-	-	-	-	-	-	664
1996	-	-	-	-	-	-	803
1997	-	-	-	-	-	-	1,077
1998	-	-	-	66	1,107	145	1,312
1999	-	-	-	181	1,621	160	1,806
2000	2,279,800	12,617,258	14,897,058	289	1,807	167	2,348
2001	2,308,326	12,412,970	14,721,296	425	2,113	131	2,748
2002	2,520,671	12,800,612	15,321,283	636	2,795	187	3,721
2003	2,792,892	13,755,924	16,548,816	821	3,612	303	4,867
2004	2,853,862	14,983,688	17,837,550	1,051	4,968	437	6,160
2005	3,115,420	15,732,277	18,847,697	1,440	5,479	524	7,564
2006	3,431,210	16,616,471	20,047,681	1,984	6,543	671	9,361
2007	3,683,132	17,138,769	20,821,901	2,578	7,739	940	11,444
2008	3,576,739	17,129,122	20,705,861	3,217	8,225	1,131	12,831
2009	3,270,928	14,744,605	18,015,533	3,561	7,595	1,051	12,240
2010	3,686,122	16,847,612	20,533,734	4,300	9,072	1,198	14,613
2011	3,632,239	17,503,465	21,135,704	5,254	9,593	1,473	16,367
2012	3,705,727	17,519,810	21,225,537	6,127	9,789	1,772	17,747
2013	3,745,813	17,744,935	21,490,748	6,940	10,060	1,941	19,021
2014	3,793,267	17,924,296	21,717,563	7,509	10,591	2,030	20,244

(continued)

Country /Region	Korea				Hong Kong		
Item	DC	IC	TC	CONT	IC	TC	CONT
Unit	TEU	TEU	TEU	TEU	10,000 TEU	10,000 TEU	10,000 TEU
From	SP-IDC	SP-IDC	SP-IDC	SP-IDC	CSD HK	CSD HK	CSD HK
1990	0	2,393,168	75,426	2,468,594	-	-	-
1991	0	2,567,035	70,344	2,637,379	-	-	-
1992	0	2,720,534	77,967	2,798,501	572	101	672
1993	0	2,940,651	191,060	3,131,711	666	107	772
1994	98,492	3,440,659	297,004	3,836,155	766	179	945
1995	116,736	3,941,679	429,649	4,488,064	795	256	1,051
1996	168,922	4,257,391	471,984	4,898,297	843	268	1,110
1997	177,787	4,711,324	585,929	5,475,040	779	396	1,175
1998	309,965	5,157,898	634,205	6,102,068	760	389	1,149
1999	294,548	5,746,810	862,457	6,903,815	792	488	1,280
2000	273,820	6,420,726	1,264,255	7,958,801	831	593	1,425
2001	288,578	6,590,750	3,110,783	9,990,111	773	646	1,419
2002	329,196	7,355,610	4,204,992	11,889,798	792	741	1,532
2003	404,791	8,182,257	4,598,823	13,185,871	800	853	1,653
2004	339,909	9,024,506	5,158,723	14,523,138	840	949	1,788
2005	271,881	9,411,826	5,532,753	15,216,460	830	1,015	1,845
2006	168,027	10,123,388	5,673,481	15,964,896	838	1,097	1,934
2007	134,347	11,254,079	6,155,497	17,543,923	771	1,220	1,991
2008	135,239	11,605,483	6,186,026	17,926,748	745	1,282	2,027
2009	253,333	10,369,184	5,718,861	16,341,378	630	1,143	1,773
2010	378,110	12,349,346	6,641,505	19,368,961	678	1,322	2,000
2011	478,380	13,412,766	7,719,356	21,610,502	645	1,425	2,070
2012	390,330	13,661,788	8,498,158	22,550,276	571	1,394	1,965
2013	200,386	13,947,620	9,321,245	23,469,251	551	1,374	1,925
2014	207,298	14,600,954	9,989,959	24,798,211	566	1,338	1,904

Remark: 1. CSD HK denotes Census and Statistics Department of Hong Kong SAR Government

Appendix 7 Japanese Input-Output Table with 13 Industries
(Leontief Inverse Matrix)

1−(4) 平成23年産業連関表 逆行列係数表 $[I-(I-\hat{M})A]^{-1}$

	01 農林水産業	02 鉱業	03 製造業	04 建設	05 電力・ガス・水道	06 商業	07 金融・保険	08 不動産	09 運輸・郵便	10 情報通信
01 農林水産業	1.120369	0.006483	0.041431	0.012434	0.006247	0.003175	0.003320	0.001391	0.007895	0.005041
02 鉱業	0.000874	1.000928	0.003236	0.001124	0.009547	0.000442	0.000294	0.000166	0.000730	0.000443
03 製造業	0.369840	0.221917	1.649602	0.423803	0.206648	0.095868	0.095841	0.040746	0.272277	0.144562
04 建設	0.012681	0.018812	0.013231	1.008485	0.056787	0.013411	0.011218	0.047488	0.022317	0.014472
05 電力・ガス・水道	0.027803	0.059303	0.043227	0.024082	1.137996	0.033676	0.015435	0.010685	0.030994	0.023277
06 商業	0.091104	0.056573	0.106375	0.107557	0.045196	1.036549	0.023977	0.011421	0.058863	0.040314
07 金融・保険	0.015022	0.049932	0.016771	0.023666	0.026823	0.026019	1.071595	0.082591	0.032283	0.014579
08 不動産	0.011169	0.023759	0.012370	0.015655	0.016243	0.042669	0.028668	1.026643	0.032054	0.039353
09 運輸・郵便	0.081057	0.283157	0.061242	0.070951	0.061567	0.070832	0.049198	0.012169	1.130086	0.046514
10 情報通信	0.018965	0.032093	0.027117	0.030224	0.038690	0.058388	0.083879	0.015011	0.031637	1.192862
11 公務	0.004152	0.002912	0.001821	0.004334	0.001985	0.002270	0.001573	0.001532	0.002742	0.002485
12 サービス	0.089856	0.160724	0.147718	0.178138	0.196897	0.127448	0.169612	0.060394	0.201201	0.262298
13 分類不明	0.018305	0.012839	0.008029	0.019103	0.008750	0.010007	0.006935	0.006755	0.012089	0.010955
列和	1.861196	1.929431	2.132170	1.919555	1.813376	1.520753	1.561547	1.316991	1.835169	1.797156
影響力係数	1.059667	1.098516	1.213945	1.092893	1.032441	0.865836	0.889062	0.749825	1.044848	1.023205

	11 公務	12 サービス	13 分類不明	行和	感応度係数
01 農林水産業	0.004386	0.011927	0.006156	1.230255	0.700442
02 鉱業	0.000451	0.000676	0.000619	1.019529	0.580466
03 製造業	0.141828	0.222573	0.208145	4.093649	2.330707
04 建設	0.025195	0.011945	0.012850	1.268892	0.722440
05 電力・ガス・水道	0.024528	0.035220	0.030920	1.497146	0.852396
06 商業	0.032231	0.066033	0.043879	1.720072	0.979318
07 金融・保険	0.048301	0.016263	0.025610	1.449455	0.825243
08 不動産	0.008721	0.021804	0.049828	1.328935	0.756625
09 運輸・郵便	0.049926	0.041368	0.107012	2.065079	1.175747
10 情報通信	0.044313	0.054679	0.071360	1.699220	0.967446
11 公務	1.000856	0.002041	0.227791	1.256495	0.715382
12 サービス	0.147970	1.151494	0.179995	3.073746	1.750029
13 分類不明	0.003772	0.008997	1.004160	1.130694	0.643758
列和	1.532478	1.645019	1.968326		
影響力係数	0.872512	0.936587	1.120661		

Appendix 8 Harmonization System Code (HS-Code)

SECTION I	
LIVE ANIMALS; ANIMAL PRODUCTS	
1	Live animals.
2	Meat and edible meat offal.
3	Fish and crustaceans, molluscs and other aquatic invertebrates.
4	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included.
5	Products of animal origin, not elsewhere specified or included.
SECTION II	
VEGETABLE PRODUCTS	
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage.
7	Edible vegetables and certain roots and tubers.
8	Edible fruit and nuts; peel of citrus fruit or melons.
9	Coffee, tea, maté and spices.
10	Cereals.
11	Products of the milling industry; malt; starches; inulin; wheat gluten.
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder.
13	Lac; gums, resins and other vegetable saps and extracts.
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included.
SECTION III	
ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE PRODUCTS; PREPARED EDIBLE FATS; ANIMAL OR VEGETABLE WAXES	
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes.
SECTION IV	
PREPARED FOODSTUFFS; BEVERAGES, SPIRITS AND VINEGAR; TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES	
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates.
17	Sugars and sugar confectionery.
18	Cocoa and cocoa preparations.
19	Preparations of cereals, flour, starch or milk; pastrycooks' products.
20	Preparations of vegetables, fruit, nuts or other parts of plants.
21	Miscellaneous edible preparations.
22	Beverages, spirits and vinegar.
23	Residues and waste from the food industries; prepared animal fodder.
24	Tobacco and manufactured tobacco substitutes.
SECTION V	
MINERAL PRODUCTS	

25	Salt; sulphur; earths and stone; plastering materials, lime and cement.
26	Ores, slag and ash.
27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes.
SECTION VI	
PRODUCTS OF THE CHEMICAL OR ALLIED INDUSTRIES	
28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, of radioactive elements or of isotopes.
29	Organic chemicals.
30	Pharmaceutical products.
31	Fertilisers.
32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints and varnishes; putty and other mastics; inks.
33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations.
34	Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial waxes, prepared waxes, polishing or scouring preparations, candles and similar articles, modelling pastes, "dental waxes" and dental preparations with a basis of plaster.
35	Albuminoidal substances; modified starches; glues; enzymes.
36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations.
37	Photographic or cinematographic goods.
38	Miscellaneous chemical products.
SECTION VII	
PLASTICS AND ARTICLES THEREOF; RUBBER AND ARTICLES THEREOF	
39	Plastics and articles thereof.
40	Rubber and articles thereof.
SECTION VIII	
RAW HIDES AND SKINS, LEATHER, FURSKINS AND ARTICLES THEREOF; SADDLERY AND HARNESS; TRAVEL GOODS, HANDBAGS AND SIMILAR CONTAINERS; ARTICLES OF ANIMAL GUT (OTHER THAN SILK-WORM GUT)	
41	Raw hides and skins (other than furskins) and leather.
42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut).
43	Furskins and artificial fur; manufactures thereof.
SECTION IX	
WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL; CORK AND ARTICLES OF CORK; MANUFACTURES OF STRAW, OF ESPARTO OR OF OTHER PLAITING MATERIALS; BASKETWARE AND WICKERWORK	
44	Wood and articles of wood; wood charcoal.
45	Cork and articles of cork.
46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork.
SECTION X	

PULP OF WOOD OR OF OTHER FIBROUS CELLULOSIC MATERIAL; RECOVERED (WASTE AND SCRAP) PAPER OR PAPERBOARD; PAPER AND PAPERBOARD AND ARTICLES THEREOF	
47	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard.
48	Paper and paperboard; articles of paper pulp, of paper or of paperboard.
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans.
SECTION XI	
TEXTILES AND TEXTILE ARTICLES	
50	Silk.
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric.
52	Cotton.
53	Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn.
54	Man-made filaments.
55	Man-made staple fibres.
56	Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables and articles thereof.
57	Carpets and other textile floor coverings.
58	Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery.
59	Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable for industrial use.
60	Knitted or crocheted fabrics.
61	Articles of apparel and clothing accessories, knitted or crocheted.
62	Articles of apparel and clothing accessories, not knitted or crocheted.
63	Other made up textile articles; sets; worn clothing and worn textile articles; rags.
SECTION XII	
FOOTWEAR, HEADGEAR, UMBRELLAS, SUN UMBRELLAS, WALKING-STICKS, SEAT-STICKS, WHIPS, RIDING-CROPS AND PARTS THEREOF; PREPARED FEATHERS AND ARTICLES MADE THEREWITH; ARTIFICIAL FLOWERS; ARTICLES OF HUMAN HAIR	
64	Footwear, gaiters and the like; parts of such articles.
65	Headgear and parts thereof.
66	Umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof.
67	Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles of human hair.
SECTION XIII	
ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA OR SIMILAR MATERIALS; CERAMIC PRODUCTS; GLASS AND GLASSWARE	
68	Articles of stone, plaster, cement, asbestos, mica or similar materials.
69	Ceramic products.
70	Glass and glassware.

SECTION XIV	
NATURAL OR CULTURED PEARLS, PRECIOUS OR SEMI-PRECIOUS STONES, PRECIOUS METALS, METALS CLAD WITH PRECIOUS METAL AND ARTICLES THEREOF; IMITATION JEWELLERY; COIN	
71	Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof; imitation jewellery; coin.
SECTION XV	
BASE METALS AND ARTICLES OF BASE METAL	
72	Iron and steel.
73	Articles of iron or steel.
74	Copper and articles thereof.
75	Nickel and articles thereof.
76	Aluminium and articles thereof.
77	(Reserved for possible future use in the Harmonized System)
78	Lead and articles thereof.
79	Zinc and articles thereof.
80	Tin and articles thereof.
81	Other base metals; cermets; articles thereof.
82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal.
83	Miscellaneous articles of base metal.
SECTION XVI	
MACHINERY AND MECHANICAL APPLIANCES; ELECTRICAL EQUIPMENT; PARTS THEREOF; SOUND RECORDERS AND REPRODUCERS, TELEVISION IMAGE AND SOUND RECORDERS AND REPRODUCERS, AND PARTS AND ACCESSORIES OF SUCH ARTICLES	
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof.
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles.
SECTION XVII	
VEHICLES, AIRCRAFT, VESSELS AND ASSOCIATED TRANSPORT EQUIPMENT	
86	Railway or tramway locomotives, rolling-stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical) traffic signalling equipment of all kinds.
87	Vehicles other than railway or tramway rolling-stock, and parts and accessories thereof.
88	Aircraft, spacecraft, and parts thereof.
89	Ships, boats and floating structures.
SECTION XVIII	
OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, PRECISION, MEDICAL OR SURGICAL INSTRUMENTS AND APPARATUS; CLOCKS AND WATCHES; MUSICAL INSTRUMENTS; PARTS AND ACCESSORIES THEREOF	
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof.

91	Clocks and watches and parts thereof.
92	Musical instruments; parts and accessories of such articles.
SECTION XIX	
ARMS AND AMMUNITION; PARTS AND ACCESSORIES THEREOF	
93	Arms and ammunition; parts and accessories thereof.
SECTION XX	
MISCELLANEOUS MANUFACTURED ARTICLES	
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated name-plates and the like; prefabricated buildings.
95	Toys, games and sports requisites; parts and accessories thereof.
96	Miscellaneous manufactured articles.
SECTION XXI	
WORKS OF ART, COLLECTORS' PIECES AND ANTIQUES	
97	Works of art, collectors' pieces and antiques.

Data Source:
http://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx

Appendix 9 Macroeconomic Statistics in Industry Wise

２．経済活動別の国内総生産・要素所得
実質：連鎖方式
（生産者価格表示）
（平成23暦年=100）

経済活動の種類 ＼ 項目	平成17暦年 (2005)			平成18暦年 (2006)			平成19暦年 (2007)		
	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産
１．農林水産業	103.8	107.7	101.4	101.9	105.4	100.0	104.2	104.0	106.0
２．鉱　　　業	155.0	134.8	225.5	143.9	121.7	217.6	135.4	116.7	199.2
３．製　造　業	105.0	108.9	98.3	108.6	112.2	102.1	113.1	116.3	107.6
４．電気・ガス・水道・廃棄物処理業	102.0	89.5	125.8	101.2	88.2	125.6	102.9	95.1	119.4
５．建　設　業	125.8	127.7	123.6	122.9	122.7	123.0	114.1	113.9	114.3
６．卸売・小売業	102.9	95.2	107.5	100.7	97.0	102.9	99.5	98.4	100.1
７．運輸・郵便業	108.8	113.5	106.4	111.4	110.8	112.5	114.0	111.0	116.8
８．宿泊・飲食サービス業	112.2	107.4	118.9	111.5	106.3	118.9	112.2	106.5	120.1
９．情報通信業	90.1	86.6	93.1	93.2	90.5	95.6	95.8	93.4	98.0
１０．金融・保険業	110.3	106.3	111.7	112.0	113.6	111.1	116.9	118.7	115.8
１１．不動産業	89.0	75.9	92.6	91.0	77.0	94.8	92.8	82.6	95.5
１２．専門・科学技術、業務支援サービス業	88.5	88.2	88.6	92.9	91.1	93.8	98.0	94.1	100.0
１３．公　　　務	97.9	97.9	97.9	96.7	92.5	98.5	97.1	91.4	99.6
１４．教　　　育	95.1	105.9	93.0	96.0	104.4	94.3	96.6	102.8	95.4
１５．保健衛生・社会事業	86.8	81.0	90.8	88.5	82.7	92.5	89.5	82.2	94.7
１６．その他のサービス	110.7	111.9	109.9	110.2	110.1	110.2	109.2	108.2	109.9

２．経済活動別の国内総生産・要素所得
実質：連鎖方式
（生産者価格表示）
（平成23暦年=100）

経済活動の種類 ＼ 項目	平成20暦年 (2008)			平成21暦年 (2009)			平成22暦年 (2010)		
	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産
１．農林水産業	105.1	98.9	113.9	103.3	102.2	105.0	101.8	104.4	98.9
２．鉱　　　業	123.4	110.0	172.7	112.7	125.5	94.6	109.1	116.8	98.2
３．製　造　業	111.1	113.3	107.4	92.3	94.5	88.4	102.5	102.4	102.8
４．電気・ガス・水道・廃棄物処理業	102.5	91.0	125.0	98.4	94.7	104.7	101.9	93.6	114.1
５．建　設　業	106.7	107.0	106.4	101.0	97.8	104.8	97.1	95.1	99.5
６．卸売・小売業	99.6	101.1	98.7	94.2	92.9	94.9	98.4	99.3	97.9
７．運輸・郵便業	112.1	110.8	113.6	101.4	105.4	98.8	102.5	103.4	101.9
８．宿泊・飲食サービス業	109.1	106.2	113.2	104.1	104.2	103.8	103.4	104.6	101.7
９．情報通信業	97.3	94.0	100.2	96.2	93.3	98.7	98.1	96.7	99.3
１０．金融・保険業	104.4	115.5	99.2	102.5	107.1	100.2	101.4	102.5	100.9
１１．不動産業	94.4	87.2	96.3	96.2	89.9	97.8	98.3	95.4	99.0
１２．専門・科学技術、業務支援サービス業	102.3	98.7	104.1	96.9	95.3	97.7	97.0	96.9	97.1
１３．公　　　務	96.3	88.2	99.8	97.7	91.5	100.4	99.6	100.6	99.2
１４．教　　　育	97.0	101.4	96.2	98.7	105.4	97.4	98.4	102.0	97.7
１５．保健衛生・社会事業	90.9	85.5	94.6	93.3	88.4	96.7	96.2	92.3	98.8
１６．その他のサービス	106.2	104.1	107.7	100.7	98.4	102.4	101.6	101.8	101.5

２．経済活動別の国内総生産・要素所得
実質：連鎖方式
（生産者価格表示）
（平成23暦年=100）

経済活動の種類 ＼ 項目	平成23暦年 (2011)			平成24暦年 (2012)			平成25暦年 (2013)		
	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産
１．農林水産業	100.0	100.0	100.0	100.3	99.9	100.6	101.3	101.6	100.9
２．鉱　　　業	100.0	100.0	100.0	99.6	108.6	86.4	102.0	107.3	93.9
３．製　造　業	100.0	100.0	100.0	101.7	101.3	102.4	100.7	99.9	102.3
４．電気・ガス・水道・廃棄物処理業	100.0	100.0	100.0	98.0	107.8	80.4	96.3	101.9	85.7
５．建　設　業	100.0	100.0	100.0	104.0	105.7	102.0	114.1	116.5	111.3
６．卸売・小売業	100.0	100.0	100.0	102.4	99.4	104.1	104.8	102.7	106.0
７．運輸・郵便業	100.0	100.0	100.0	102.4	102.6	102.4	102.7	102.2	103.1
８．宿泊・飲食サービス業	100.0	100.0	100.0	101.3	105.4	95.6	101.1	100.9	101.4
９．情報通信業	100.0	100.0	100.0	101.9	103.6	100.4	104.2	105.2	103.3
１０．金融・保険業	100.0	100.0	100.0	101.1	97.7	102.8	107.8	100.3	111.6
１１．不動産業	100.0	100.0	100.0	101.0	103.7	100.3	102.4	104.3	101.9
１２．専門・科学技術、業務支援サービス業	100.0	100.0	100.0	100.1	99.7	100.4	101.8	100.9	102.2
１３．公　　　務	100.0	100.0	100.0	100.0	100.5	99.8	101.6	107.2	99.2
１４．教　　　育	100.0	100.0	100.0	101.0	100.9	101.0	101.6	102.7	101.3
１５．保健衛生・社会事業	100.0	100.0	100.0	104.1	104.0	104.1	106.6	106.6	106.6
１６．その他のサービス	100.0	100.0	100.0	101.9	103.1	101.1	100.8	103.1	99.1

２．経済活動別の国内総生産・要素所得
実質：連鎖方式
（生産者価格表示）
（平成23暦年=100）

経済活動の種類 ＼ 項目	平成26暦年 (2014)			平成27暦年 (2015)		
	産出額	中間投入	国内総生産	産出額	中間投入	国内総生産
１．農林水産業	99.8	101.6	97.6	98.0	105.3	88.9
２．鉱　　　業	100.6	107.4	90.6	98.1	114.8	74.5
３．製　造　業	102.5	101.2	105.2	102.4	100.1	107.4
４．電気・ガス・水道・廃棄物処理業	95.6	100.3	86.6	94.7	105.1	76.2
５．建　設　業	114.9	114.4	115.6	115.4	114.2	117.0
６．卸売・小売業	100.4	97.7	101.9	100.6	96.6	102.9
７．運輸・郵便業	104.7	103.5	105.5	104.7	110.0	101.1
８．宿泊・飲食サービス業	100.6	99.3	102.4	101.2	99.5	103.6
９．情報通信業	104.7	105.7	103.8	106.7	108.1	105.5
１０．金融・保険業	107.2	98.5	111.6	112.9	104.6	117.2
１１．不動産業	103.4	104.3	103.1	104.2	103.8	104.3
１２．専門・科学技術、業務支援サービス業	101.4	102.2	100.9	103.7	105.9	102.6
１３．公　　　務	100.9	103.9	99.6	101.3	105.3	99.5
１４．教　　　育	102.2	103.4	102.0	103.2	105.9	102.6
１５．保健衛生・社会事業	107.9	112.7	104.8	112.2	116.1	109.6
１６．その他のサービス	99.3	99.9	98.9	97.8	99.1	96.9

Notes

1. Japanese 2011 Annual Report of Port Statistics, MLIT. pp.5
   (港湾統計年報（平成２３年分）の概要　３．用語)
   （４）「コンテナ（コンテナ貨物)」とは、港湾において船卸し又は船積みされる時点の貨物がコンテナに収容されているものをいう。また、「空コンテナ」とは、貨物を収容していないコンテナをいう。
2. Maritime Economics, 3rd Edition, Martin Stopford, Chapter 13 “Transport of General Cargo”, Section “The container system 1966-2005” pp.508
   “For the liner business the solution was to unitize general cargo using containers. Standardizing the cargo unit allowed liner companies to invest in mechanized systems and equipment which would automate the transport process and raise productivity. The whole procedure was essentially an extension of the production line technology which had been applied so successfully in manufacturing industry and bulk trades such as iron ore. The new system had three components. First, the product transported, general cargo, was packed in standard units that could be handled across the whole transport operation. Several other systems such as palletization and barges were considered, but containers were chosen by all the major operators. Second, investment was applied at each stage to produce an integrated transport system with vehicles at each stage in the transport chain built to handle the standardized units. On the sea leg the investment was in purpose-built cellular container ships. On land it required road and rail vehicles capable of carrying containers efficiently. Finally, the third step was to invest in high-speed cargo-handling facilities to transfer the container between one part of the transport system and another. Container terminals, inland distribution depots and container‘stuffing’facilities where part loads could be packed into containers all played a part in this process.”
3. Review of Maritime Transport 2013, UNCTAD, Chapter 1 pp.21
   “For many decades, containerized trade has been the fastest-growing market segment accounting for over 16 percent of global seaborne trade by volume in 2012 and more than half by value (in 2007).”
4. Maritime Economics, 3rd Edition, Martin Stopford, Chapter 13 “Transport of General Cargo” pp.515
   “This means commodity analysis, even when it is possible for a few of the larger trades, does not tell the whole story and is not really practical. So we might as well accept at the outset that this is a highly complex business and analysts must expect problems getting to the bottom of it. A good starting point is the relationship between container cargo and world economic activity.”
5. Japanese 2011 Annual Report of Port Statistics, MLIT. pp.4
   (港湾統計年報（平成２３年分）の概要（イ）調査項目)
   ３）コンテナ個数・シャーシ台数
   ①　コンテナ個数
   貨物を輸送するために用いられたコンテナ及び回送中の空コンテナの個数とし、ＴＥＵに換算した。
6. RWI - Leibniz Institute for Economic Research (formerly Rheinisch-Westfälisches Institut für Wirtschaftsforschung) is a leading centre for economic research and evidence-based policy advice in Germany. The Institute was founded in 1926. Since 1943 it is an independent research institute. RWI is a registered, non-profit institution and is committed to serving the common good. RWI is supported by the Federal Government and by the Bundesland North Rhine-Westphalia.
7. ISL - Institute of Shipping and Logistics was established on March, 30th 1954 in the legal form of a non-profit private foundation, with the purpose to carry out scientific research and to promote shipping. The ISL combines tradition with modern science and have since positioned itself as one of Europe’s leading institutes in the area of maritime logistics research, consulting and knowledge transfer.
8. RWI/ISL Container Throughput Index (https://www.isl.org/en/containerindex)
   “Calculations since 2007 show that the Container Throughput Index is very closely correlated with the data on world trade, which are published by the International Monetary Fund (IMF). In particular, during the financial and economic crisis in 2008/2009, the index provided reliable data. As the German economy is heavily export-oriented, the assessment of the international economy is an essential basis for analysis. Against this background, the RWI/ISL Container Throughput Index

helps to forecast the German economy effectively."

9. Maritime Economics, 3rd Edition, Martin Stopford, Chapter 17 "Maritime Forecasting and Market Research", Stage 2 "The seaborne trade forecast" pp.718-720 (See below Figure 1)
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11. 2011 Input-output Table Explanatory Report, Ministry of Internal Affairs and Communications Japan, 2015, pp.29-36
12. 2011 Input-output Table Explanatory Report, Ministry of Internal Affairs and Communications Japan, 2015, pp.37-52
13. The Background Information Report of RWI/ISL Index (https://www.isl.org/public/pages/consulting-and-transfer/rwi-containerindex/Hintergrundinformation_Containerindex.pdf)
    "Firstly, containers have only gradually ousted conventional bulk cargo transporting. However, container throughput rose faster than the containerized trade in the seaports, as the penetration of hub and spoke systems because stronger. In such systems, the containers were not only handled in the actual source and destination seaports, but also transshipped between different container shipping lines in so called seaport hub."

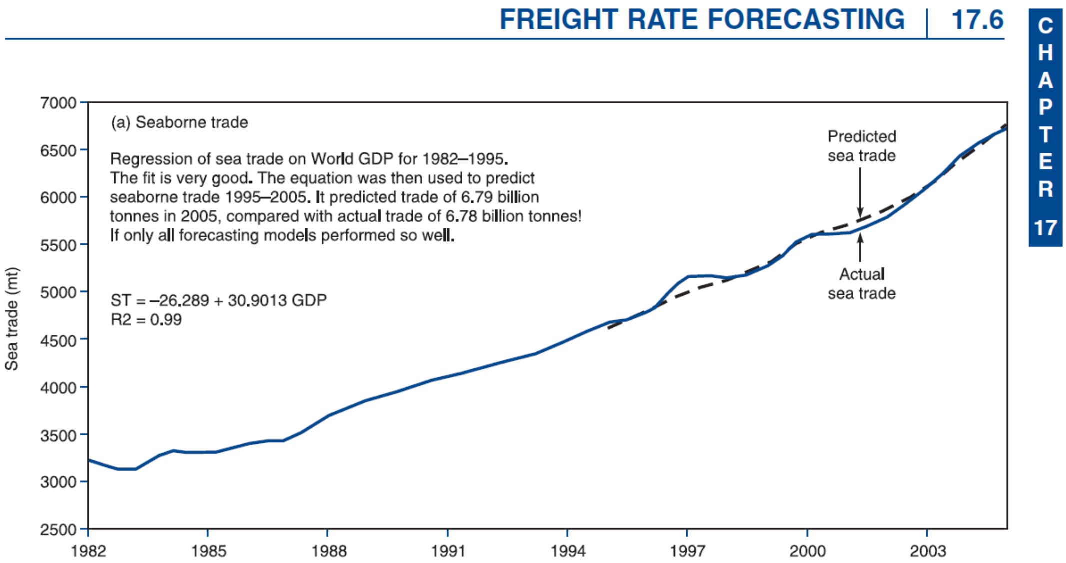

Figure 1 Linear Regression Analysis for World Seaborne Trade and World GDP

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