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MECHANISM OF BULK CARGO CONTAINERIZATION
（バルク貨物コンテナ化のメカニズム）

by

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Submitted to the Department of International Development Engineering
in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

at

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Abstract

Prior to containerization, consumer goods shipped by sea were termed “general cargo.” With the development of containerization in the 1960s, the transportation of cargo changed dramatically, leading to the global phenomenon known as the “container revolution.” The impact of containerization has been enormous because it not only reduces transport costs but also improves the safety and reliability of transportation and promotes international trade. Although containerization progressed after standardization in the late 1960s, progress slowed in the 2000s. Both academics and practitioners recognized that this was primarily the result of the completion of the process of conversion from general cargo. Therefore, it is important to increase container cargo in the future by exploiting niche markets and goods that are not traditionally carried by container shipping. Thus a focus on bulk cargo containerization (BCC) is essential.

Further, BCC can also lead to increased efficiency in container shipping because it helps to alleviate differences between outbound and inbound freight and it reduces the cost of returning empty containers to the export port. Thus, promoting BCC is of great significance in terms of increasing both the freight revenue and efficiency of container shipping companies.

The primary purpose of this dissertation is to observe how containerization of bulk cargo takes place and the factors that are involved in promoting this mode of transport. To this end, the author attempts to identify both the macroeconomic and microeconomic factors affecting BCC. Macroeconomic factors include the status of various economies and their infrastructure, while microeconomic factors include specific BCC decision-making entities, the relationships between those decision-making entities, and the structure of the decision-making process. In addition, various research hypotheses are tested and policy measures aimed at promoting BCC are proposed.

First, the factors involved in promoting BCC in the East Asia region are analyzed using cluster analysis and simultaneous equation modeling. Then, based on interviews with practitioners, the decision-making structure is examined. Second, using a calculation based on the consignee’s cost function and the container shipping company’s profit function, BCC selection factors, decision-making processes, and proposed BCC promotion measures are analyzed. It is found that cost reduction for consignees plays a significant role in promoting BCC. Further, a combination of policies in relation to other factors, including cargo handling costs, procedural expenses, and improved container port and equipment performance is necessary if BCC is to be promoted. The findings also indicate that it is essential to focus on characteristics such as demand size.

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Abbreviation

ASEAN	Association of Southeast Asian Nations
BCC	Bulk Cargo Containerization
BDI	Baltic Dry Index
CAC	Central America and the Caribbean
CFS	Container Freight Station
CIF	Cost, Insurance and Freight
EU	European Union
FAK	Freight All Kinds
FCA	Free Carrier
FE	Far East
FEU	Forty-Foot Equivalent Unit
FIO	Free in Out
FOB	Free on Board
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
ICT	Information and Communications Technology
IMF	International Monetary Fund
IS	Indian Subcontinent
ISIC	International Standard Industry Classification
JPY	Japanese Yen
LA	Los Angeles
LPI	Logistics Performance Index
ME	Middle East
MT	Metric Ton
OD	Origin and Destination
PSW	Pacific South West
SITC	Standard International Trade Classification
TEU	Twenty-Foot Equivalent Unit
THC	Terminal Handling Charge
UNCTAD	United Nations Conference on Trade and Development
USD	United States Dollar
WB	World Bank
WTI	West Texas Intermediate

CHAPTER 1

INTRODUCTION

1.1 Background

Since the container revolution of the 1960s, containerized cargo shipping has continued to increase worldwide. Until container shipping commenced, flexible, multi-deck general cargo carriers with appropriate handling equipment usually carried goods such as consumer products, which were called "general cargo." The cargo was loaded mainly by humans, in what was a labor-intensive process.

A container transportation system enables cargo to be carried in rectangular containers that are of standard size throughout the world. Containers are stored in yards on quays, from which they are loaded onto container ships. A container transportation system enables significant savings in terms of the energy required for loading and unloading of vessels and shortens the vessels' mooring time. Further, because the containers are of uniform shape and size, it has become possible to send them directly from the shipper to the consignee using not only ships but also a variety of other means of transport such as rail and road. This not only dramatically reduces the cost of cargo transport but also improves the safety and reliability of transportation, thus significantly promoting international trade.

Containerization has also been recognized as a driving force behind globalization. Drucker (2007) noted that container shipping was indispensable in relation to the tremendous expansion in world trade from the 1960s to the 2000s. In addition, Krugman (2009) commented in a lecture that "When we think about technology that changes 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 strong case to be made that it was containers."

As container shipping has become established, the proportion of cargo carried in containers has also increased. The weight-based ratio of container shipping to all global ocean cargo (containerization rate[1]) rose from 4.5% in 1986 to 14.6% in 2008 and the transportation of

[1] Before the development of containerization, cargo freight rates varied depending on the nature of the cargo, even when the size and weight were the same. However, with the development of containerization, in cases

general goods such as consumer products, which were the initial focus of the increase in container cargo, increased significantly until the first half of the 2000s.

However, growth in the containerization rate has stagnated since the latter half of the 2000s, and the rate was still only 15.8% in 2017 (see Figure 1.1). A primary reason for this stagnation is that containerization of general cargo, which had been central to the increase in container cargo, has now become standard. Rodrigue and Notteboom (2015) argue that although containerization of general cargo was increasing until 2007, there has been no change since then, particularly in developed countries.

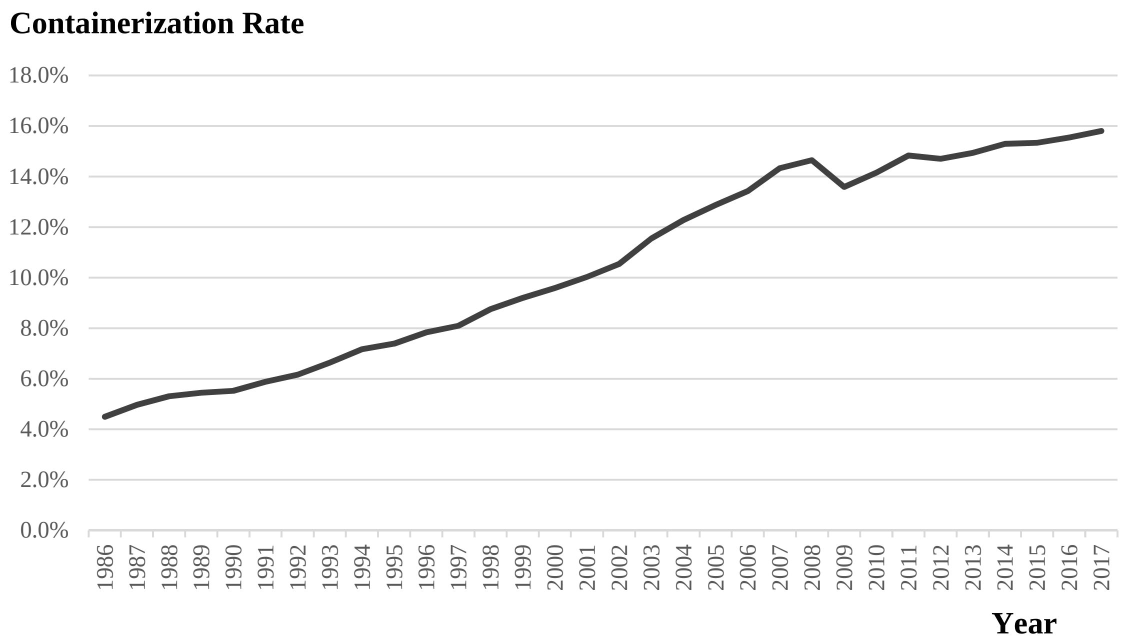

Figure 1.1 Global Containerization Rate

Source: Clarksons Research Shipping Intelligence database

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where no dangerous goods are involved, even if the contents differ, the calculation of freight (FAK rate) per container is constant, with shipping companies mainly taking into account cargo volume rather than cargo value. The value-based containerization rate, defined as the value of container cargo divided by the value of all seaborne trade cargo, seems to be an inappropriate measure for containerization because it tends to correlate with other economic factors such as the foreign exchange rate and the oil price. Thus, the decision was made to use the weight-based containerization rate in this dissertation.

The existence of imbalances in cargo movements between mainhaul[2] and backhaul is also a fundamental problem in container shipping. This imbalance has increased since the latter half of the 1990s because of the structural changes in global production networks. In 2017, the imbalance in the container trade volume amounted to 34.7 million TEU, or 21.4% of global containerized transportation via interregional routes. With container shipping, it is essential to maintain schedules, and thus it is more difficult to resolve this imbalance than in the case of bulk shipping. Of the overall operating expenses of container carriers, 5–8% are repositioning expenses, and the financial burden for the container shipping industry as a whole is between 15 and 20 billion USD (Sanders *et al.*, 2016).

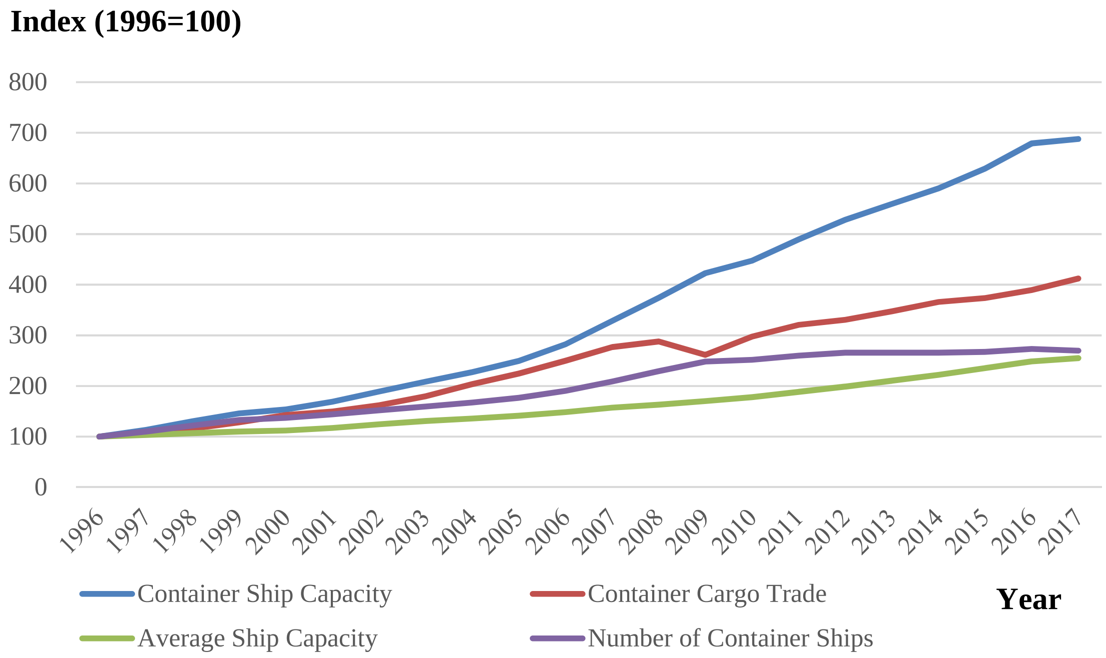

Figure 1.2 Global Growth in Container Ship Capacity, Container Cargo Trade, Average Ship Capacity and Number of Container Ships

Source: Clarksons Research Shipping Intelligence database

[2] The term "mainhaul" does not appear in many English dictionaries. However, this term is often used by practitioners to indicate the direction of trade that is larger in volume. For example, the mainhaul for the container trade route between East Asia and North America refers to the route (or direction) from East Asia to North America. The antonym for "mainhaul" is "backhaul." Thus, the backhaul for the above route is the direction from North America to East Asia.

Moreover, as shown in Figure 1.2, container ship capacity is growing, in terms of both average capacity and ship numbers. In 1996, the average container ship capacity was 1,527 TEU and there were 1,911 ships. However, by 2017, the average capacity was 3,895 TEU and there were 5,151 ships. This growth in shipping capacity has been much faster than that of container cargo trade, resulting in an excess supply of container shipping. Hence, container shipping companies are suffering from the deterioration in market conditions as a result of shrinking margins for container cargo and increased supply. Therefore, container shipping companies, container terminal operators, and other industry participants involved in logistics are seeking new types of container cargo.

To mitigate the problems related to container shipping, it is necessary to either reduce the supply of container transportation services or expand the demand for container transportation services. However, a decline in the supply of services will lead to a reduction in international trade, which will reduce profits. Therefore, a solution that increases the demand for container transportation services is preferable. Rodrigue and Notteboom (2015) argue that it is crucial to develop niche markets and acquire commodities that have not previously been transported by container. One possibility is bulk cargo containerization (BCC), which is the focus of this dissertation.

BCC involves the use of shipping containers to freight cargo that is usually transported by bulk carriers, and is receiving increasing attention from both practitioners and academics as a potential solution to the problems currently confronting container shipping. BCC not only has the potential to increase the volume of cargo shipped by container but also offers an opportunity to increase efficiency because the principal types of cargo that can be freighted using BCC are also likely to be backhauled (UNCTAD, 2013). However, to the best of the author’s knowledge, there have been no previous studies adopting a holistic approach to BCC and proposing a mechanism for BCC. Therefore, this dissertation seeks to answer the following questions to clarify the mechanism by which BCC might emerge.

The first question relates to the potential of BCC from the macroeconomic perspective. That is, what are the potential benefits and challenges of an increase in container shipping as a result of BCC? The second question involves the decision-making structure. That is, who is engaged in the decision-making process and what factors are important to them in their decision-making regarding the preferred transportation mode. The third question relates to the potential of BCC from the microeconomic perspective. That is, do decision-makers have incentives to containerize bulk cargo, and if so, what methods should be used to promote BCC?

1.2 Research Objectives

The primary purpose of this dissertation is to identify the mechanism underlying BCC, that is, how BCC takes place and the most effective methods of promoting this mode of transport. To this aim, both macroeconomic and microeconomic factors related to BCC are examined. Macroeconomic factors include the status of various countries' economies and infrastructure, while microeconomic factors include specific decision-making entities, the relationships between those entities, and the structure of the decision-making process. Therefore, the dissertation proceeds in terms of research objectives 1 to 3 presented below. In addition, policy measures to promote BCC based on the results of the analysis are proposed.

Research Objective 1:

Conducting an econometric analysis and identifying the macroeconomic factors related to promoting BCC as an important background for decision-making by agents.

- Classification of traded goods to analyze trends toward containerization.
- Development of an econometric model taking into account simultaneity and endogeneity to identify the macroeconomic factors related to container shipping in East Asia.

Research Objective 2:

Identifying the decision-making agents and factors affecting the change in transportation mode between bulk shipping and container shipping.

- Analysis of factors affecting decision-making by practitioners in relation to BCC using an interview-based survey.

- Organization of these decision-making factors and the decision-making structure regarding BCC into a hypothesis related to Research Objective 3.

Research Objective 3:
Assessing whether decision-makers have economic incentives to execute BCC by comparing their costs and profits

- Assessment of the choice of transport mode by backhaul consignees between bulk and container shipping based on total costs including purchase costs, tariffs, and changes in the value of the goods.
- Assessment of the choice of services offered by container shipping company based on total profits from both mainhauling and backhauling.

1.3 Study Scope

The scope of this dissertation involves containerization, including the recent stagnation and trade imbalances that have occurred, and the choice between container shipping and bulk shipping.

BCC is not a new form of containerization but it is not widely used and focused among practitioners. Thus, clarification of the mechanism underlying BCC adds to the literature on containerization, and is a contribution of this dissertation. To derive the mechanism underlying BCC, the structure of BCC is analyzed based on both macroeconomic and microeconomic factors. That is, the impact of economic conditions and infrastructure, decision-making entities regarding BCC, the relationships between those entities, and the structure of the decision-making process are examined. This contributes to the literature regarding maritime economics and logistics studies because it clarifies the mechanism underlying containerization as it enters a new stage.

It is worth noting that there are other means of increasing container cargo. For example, the development of a supply chain using refrigerated (reefer) containers facilitates the transport of foodstuffs, medicines, chemicals, and beverages (Rodrigue and Notteboom, 2015). These innovations have added value to containerized transportation, especially among developed countries. However, the volumes of these products are significantly less than those of bulk cargo, and sometimes reefer containers are used to backhaul bulk cargo[3]. In addition, BCC could be used to alleviate this imbalance when establishing a cold transport chain. Therefore, BCC is the focus of this dissertation.

Further, regarding the choice of transport mode, previous studies have tended to focus on a choice between maritime container transport and air transport because of similarities in the types of products and contracts involved. Although numerous practitioners have addressed the changing trends in containerization, there has been a lack of research on the choice of transport mode. Therefore, it is important not only from an academic perspective but also for practitioners to find the boundary or threshold of the change in transport mode between bulk shipping and container shipping. Research on BCC provides useful information in relation to the acquisition of new types of cargo and the selection of the appropriate transport mode.

1.4 Dissertation Outline

The dissertation is divided into seven chapters, as shown in Figure 1.3. Chapter 1 provides the background, problem statement, and purpose and objective of the dissertation.

Chapter 2 outlines the current status of containerization in general and the containerized shipping of bulk cargo in particular. First, the status of containerization in terms of diffusion and stagnation is reviewed. Then, the current problem in terms of container shipping, trade imbalances, and repositioning is stated. Next, the containerization of bulk cargo is introduced as a potential new cargo source. Then, the current status of containerization in terms of types of goods, value, and routes is outlined. Finally, the characteristics and benefits of BCC are presented. Also, in Chapter 2, a preliminary analysis of the current situation regarding BCC

[3] Tank containers are not used to backhaul bulk cargo because tank containers are usually dedicated to specific goods such as wine or chemical products. Thus, in many cases shippers or consignees own these containers, and take repositioning costs into account in advance.

is conducted, and this is used as a reference for the analyses conducted in Chapter 4 and later chapters.

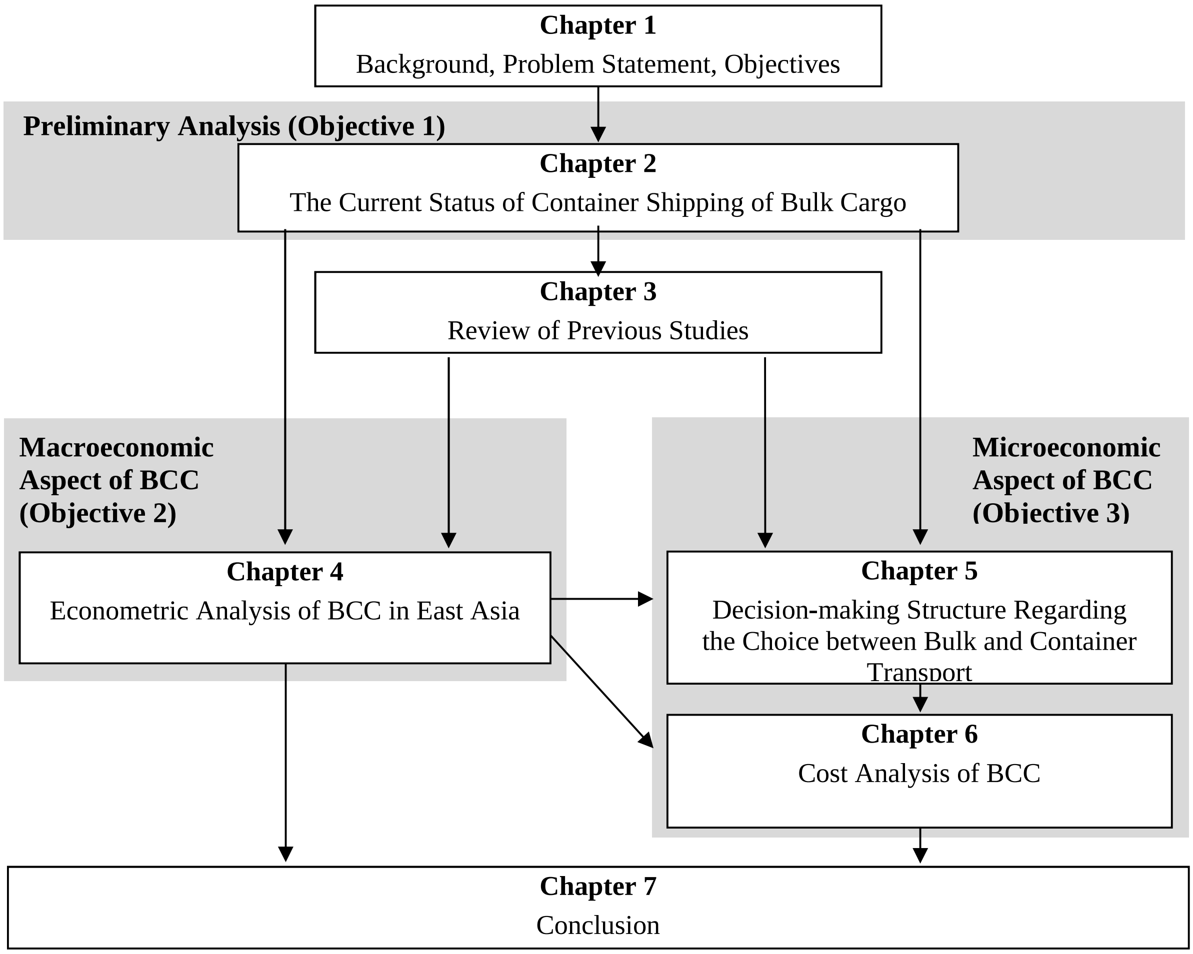

Figure 1.3 Organization of Dissertation

Chapter 3 presents a review of the literature concerning containerization and international trade issues, the benefits of containerization, and previous studies on BCC. The literature regarding choice of transportation mode is also reviewed because BCC is related to the choice between bulk shipping and container shipping.

Chapter 4 examines the macroeconomic aspect of BCC by identifying factors that should encourage containerization in intra-East Asian trade. First, an analysis of intra-East Asian seaborne trade is conducted using *k*-means clustering to identify trends toward containerization of various commodities on various trade routes. Then, an analysis is conducted using simultaneous equation modelling to identify the critical factors that promote containerization in each cluster. In Chapter 4, the relationship between the macroeconomic environment and containerization in its aggregated form is considered using econometric analysis. In other words, the background is provided for the decision-making analyses that are conducted in Chapters 5 and 6.

Chapter 5 examines the decision-making structure in relation to BCC using an interview-based survey. The decision-making factors related to shipping companies, logistics companies, and shippers are summarized, and the primary decision-makers in relation to BCC are identified based on the survey results. The measures necessary to promote BCC are then identified.

Chapter 6 presents a core part of the analysis regarding the decision-making structure in relation to BCC. Based on the results presented in Chapter 5, the incentives for consignees and container shipping companies are analyzed to identify the decision-making process and key factors in the selection of BCC, as well as proposed BCC promotion measures.

Chapters 5 and 6 present the factor analysis undertaken in Chapter 4 in more detail by decomposing the results into those relating to individual decision-makers. In Chapter 5, based on interviews with practitioners, the decision-making factors relating to individual decision-makers in relation to BCC are shown, and the decision-making structure is illustrated. In Chapter 6, the results of Chapter 5 are used as the basis for analysis and the hypotheses that are constructed based on the results presented in Chapter 5 are verified.

Chapter 7 provides concluding remarks and discusses the practical applicability of the findings of the dissertation and areas for future work.

CHAPTER 2

THE CURRENT STATUS OF CONTAINER SHIPPING OF BULK CARGO

2.1 Introduction

Because ships are suitable for mass transport, they are indispensable in international trade. In 2017, maritime transport accounted for 69.4% of global trade based on weight, and 54.4% based on value. Containerization of maritime cargo has advanced since the middle of the 20th century, and has played a critical role in strengthening the global economy.

The reason that BCC, which is the subject of this dissertation, is attracting increasing attention is that containerization has expanded rapidly over the last half century, while the amount of cargo that can be transported in containers has stagnated. Thus, BCC provides an opportunity for containerization in the future. This chapter outlines the current situation regarding BCC in relation to the progress of containerization. Then, the stagnation of growth in containerized cargo and the significant factors in relation to this problem are outlined. Next, the problem of imbalance is described. Imbalance is also a problem with bulk carriers, but the problem is even greater for container ships that must adhere to tight schedules and carry containers on their return journey, regardless of whether they contain cargo. The emergence of bulk cargo as a potential new source of cargo that can reduce this imbalance for container shipping companies is described. Then, the current bulk cargo transportation process and the container shipping process are examined to illustrate the difference between these transportation modes. Next, the current status of containerization in general and BCC in particular are presented. Finally, the advantages of BCC for both shipping companies and shippers/consignees are outlined.

2.2 Diffusion of Containerization

Stopford (2009) outlined the situation prior to the introduction of containerization. Until the 1960s, when containerization began to spread, shipping companies operated flexible multi-deck carriers fitted with handling equipment. Flexibility was important because the ships had to transport various types of cargo in combination with passengers. This business was labor-intensive, time-consuming, and complicated. Moreover, cargo was frequently damaged. After WWII, as international trade began to increase, exporters/importers began to demand international transport services that were faster, more reliable, and safer. The solution to this problem was “containerization,” which standardized the transport of general cargo by using containers. By standardizing the cargo unit, the shipping company could invest in mechanized systems and facilities that increased productivity.

One benefit of containerization was to increase the efficiency of cargo handling and port operations. From April 1956, when the Ideal-X, the first ship to carry containers, departed from New Jersey bound for Houston carrying 58 35-foot containers, there was an ongoing reduction of costs. The estimated loading cost for the Ideal-X was 15.8 cents per ton, whereas the estimated loading cost for cargo not packed into containers was $5.90 per ton at that time (Bernhofen *et al*., 2016). In addition, Bernhofen *et al.* (2016) pointed out that the labor productivity of the port, which was 0.627 tons per person per hour in 1959, increased sharply to 4,234 tons per hour by 1976. As the efficiency of loading and unloading improved, it became possible to use larger vessels for transportation of cargo by containerization, and as a result, the average size of vessels increased.

The ability to establish an intermodal system (seamless transportation by land and sea) is another benefit of containerization. The spread of the multimodal system has made it easier to distribute production bases and establish global supply chains. For example, parts processed in Southeast Asia can be sent to China for assembly and then exported to Japan, Europe, and the United States (US). This has reduced transportation costs and expanded global trade. In this regard, Levinsohn (2006) stated that “Transportation has become so efficient that for many purposes, freight costs do not much effect economic decisions.”

Despite these benefits, the adoption of this new system was somewhat slow in the beginning (Rua, 2014; Guerrero and Rodrigue, 2012). By 1968, containerized trade was still minimal, accounting for less than one million TEUs or 1% of total trade (Fenton *et al*., 2018). Shippers were unwilling to adopt the new system immediately, preferring to wait until they were sure that containerization would prevail and an industry standard for containers and their handling had been established (Koech, 2013). In 1964, dimensions of 10 feet, 20 feet, 30 feet, and 40 feet long, and eight feet high and eight feet wide were approved as ISO standards, and then in 1966, a height of 8 feet 6 inches was added (see Figure 2.1 and Table 2.1). The prevailing American standards became the international standards, and from this point on leasing companies began to order large numbers of containers, leading to the rapid development of containerization (Watanabe *et al*., 2008). Adoption followed an S-shaped pattern and occurred throughout the world during the 1970s and 1980s. By 1983, almost 90% of countries had constructed at least one container port (see Figure 2.2).

Figure 2.1 Standardized Containers (Left : 20 foot, Right : 40 foot)
Source: Mr. Tomohide Nogaki of Japan Shipowners' Association

Table 2.1 Specification of Standardized Containers

Size	Length (mm)	Width (mm)	Height (mm)	Weight (kg)	Load limit (kg)	Capacity (m3)
20 foot	5,898	2,352	2,393	2,300	21,700	33.0
40 foot	12,032	2,352	2,393	3,810	26,670	67.7
40 foot High Cube	12,032	2,352	2,698	3,970	26,510	76.0
45 foot High Cube	13,557	2,352	2,698	4,820	25,660	86.0

Source: Usui (2012)
Note: Specifications differ slightly between container manufacturers.

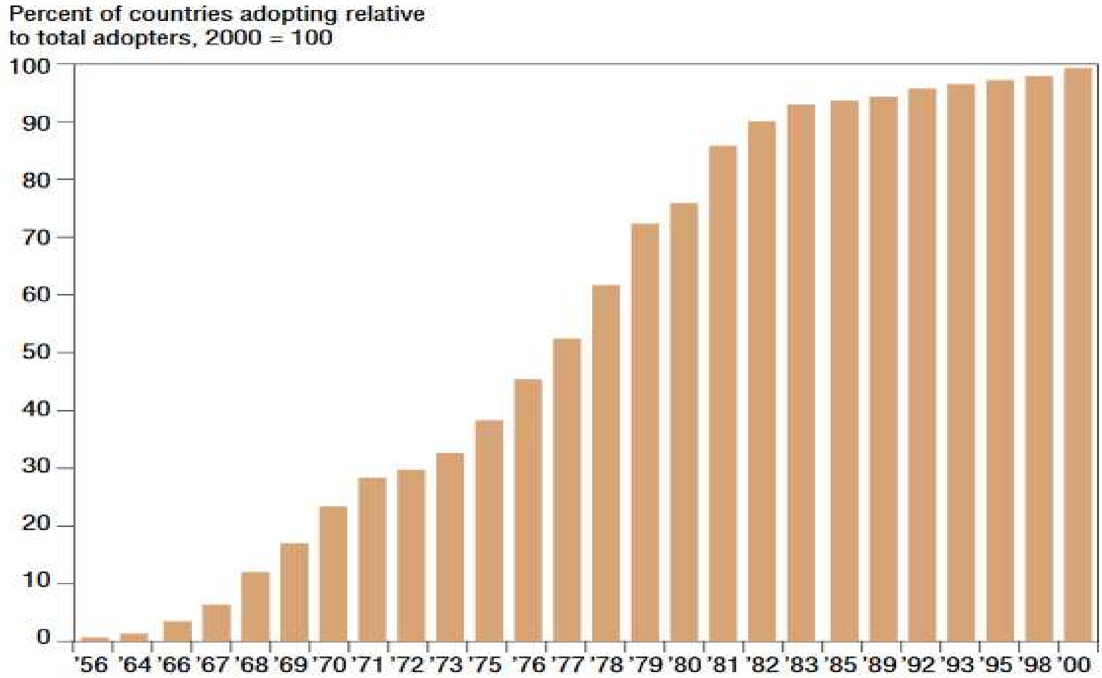

Figure 2.2 Adoption of Containerization following Container Standardization

Source: Koech (2013)

Note: The year of containerization adoption is defined as the year in which the first container port was constructed. The figure shows the percentage of countries engaged in international maritime trade that adopted containerization by a given date relative to the total number of adopters at the beginning of the 21st century.

Guerrero and Rodrigue (2012) divide the stages of containerization from 1970 to 2010 into five "long waves" (see Table 2.2). The first wave is that referred to above, when standardization and containerization were yet to be adopted in any significant way. This is termed the early-adopters stage. By the 1970s, liner transatlantic and transpacific services had been established through ports in the US, Western Europe, and Japan. This was the economic triad that spearheaded globalization at that time. The second wave can be regarded as the expansion of containerization, and occurred among this triad and its trade partners in regions such as the Caribbean, the Mediterranean, and newly industrialized economies in Asia. The third wave was the global diffusion stage. Container handling volumes grew in East and Southeast Asia (excluding China). During that period, these areas were incorporated into global trade relationships with the commencement of offshoring and the emergence of new transshipment hubs such as Singapore.

Table 2.2 Waves of Containerization, 1970–2010

Period	1956(1965)-1975	1970-1985	1980-1990	1995-	2005-
Overview	Pioneer ports established containerized operations in the economic triad (North America, Western Europe, and Japan)	Expansion of the triad and its trade partners (Caribbean, Mediterranean, Asian Tigers)	Large diffusion into new markets (Latin America, Middle East/South Asia, Southeast Asia	The container became the standard transport unit for the global economy, "The China Wave"	Peak growth and the establishment of niches
Driver	Early trade substitution	Adoption of Containerization	Setting up of global supply chains and transshipment hubs	Expansion of global supply chains, and the emergence of China and transshipment hubs	Spillover effect and new transshipment hubs
Representative ports	Antwerp, New York, Los Angeles, Oakland, Nagoya	Rotterdam, Tokyo, Hong Kong, Kaohsiung, Jeddah, Kingston	Singapore, Colombo, Busan, Dubai, Algeciras	Shanghai, Shenzhen, Gioa Tauro, Ningbo, Tanjung Pelepas	Tangier Med, Caucedo, Yingkou, Prince Rupert

Source: Guerrero and Rodrigue (2012)

The fourth wave occurred in the late 1990s, when containers became established as a global standard for transporting cargo. Chinese ports were included in global shipping networks and post-Panamax ships[4] started to appear. Moreover, new transshipment hubs such as Salalah in Oman and Colon in Panama emerged. In addition, new ports were developed during this period to accommodate the growth in emerging economies such as Vietnam, India, and Brazil. A transshipment hub was also developed in Tanjung Pelepas in Malaysia by global terminal operators. Kavirathna *et al.* (2018) note that competition among hub ports became

[4] A "Panamax" ship was a vessel that was able to navigate the old locks along the Panama Canal, which included container ships up to about 5,000 TEUs in capacity. By the latter half of the 1980s, many practitioners had assumed Panamax restrictions to be the upper limit of a container ship's capacity.

increasingly fierce around this period. The fifth and most recent wave has seen newly emerging ports meeting various concerns by filling specific roles such as avoiding congestion, reducing transit time, and providing direct rail connections. In addition, they point out that the fifth wave has seen a pause in the growth of container shipping.

2.3 Stagnation of Containerization

Evidence emerged from the late 2000s onwards suggesting that the growth in container shipping may not be sustainable in the future. The containerization rate rose from 4.5% of global ocean freight in 1986 to 14.6% in 2008. However, as the upward trend in general cargo, which was the driving force behind the increase in container cargo, weakened, the containerization rate stagnated from the latter half of the 2000s, and was steady at 15.8% in 2017. Rodrigue and Notteboom (2015) point out that containerized freight increased from 21% of general cargo in 1980 to around 65% from 2007 to 2012. Fenton *et al.* (2018) note that container cargo accounted for 21% of dry seaborne cargo in 2005, but was still only 23% in 2015.

An important reason for this stagnation is that the containerization of general cargo, which has been the driving force behind the increase in container cargo to date, has now been more or less optimized. Rodrigue and Notteboom (2015) point out that, particularly in developed countries, the completion of the conversion to containerized transport is rapidly approaching. It has been shown that the switch to container shipping has already occurred for most goods that can be transported in this way. Fenton *et al.* (2018) note that the slowdown in containerization is inevitable because many commodities have already become fully containerized.

Another primary reason for this stagnation is that changes in the global economic structure have reduced promotion effect by economic growth on international trade. Takatomi *et al.* (2016) and Mori (2016b) both pointed out that trade growth has failed to match economic growth. First, there has been a change from investment- to consumption-centered economic structures in developed countries in the 21st century. Second, there has been significant technological progress in countries such as China and members of the ASEAN. Third, it can be seen that there has been a pause in the expansion of the global value chain. These factors have had an impact on container transportation volumes. The average ratio of the container freighted growth rate to the global real economic growth rate was 3.2 from 2000 to 2008. However, since 2009, it has fallen to 2.1 (Rodrigue, 2017). Fenton *et al.* (2018) confirm this finding, stating that "as the wave of globalisation has slowed, container growth is only just matching GDP growth."

2.4 Imbalances in Container Shipping

The existence of imbalances in cargo movements on container routes is a fundamental reason for recommending the shift from bulk carriers to container vessels. Asymmetries in container trade volumes exist on several container routes, and as can be seen in Table 2.3, the imbalance in 2017 amounted to 34.7 million TEUs or 21.4% of global container transportation via interregional routes. As for intraregional routes, there was an imbalance of 1.3 million TEUs during 2017 for the Japan–China route according to IHS Markit's World Trade Service.

There was an upward trend in trade imbalances from the latter half of the 1990s, with structural changes in global production networks leading to substantial endemic increases. These imbalances have since escalated as a result of low export demand in the US and European countries and the low cost of manufacturing new containers in countries such as China[5]. For instance, imbalances increased from 18% for transpacific trade and 27% for FE–Europe trade in 1995 to 67% and 65%, respectively, in 2005 (Theofanis and Boile, 2009).

[5] Container manufacturing was initially concentrated in the US. Then, Japan emerged as the dominant player, until Korea took its turn in the 1980s, during which time Korean companies produced more than 70% of the world's shipping containers. The Chinese container manufacturing industry had barely begun in the 1990s, but rapidly increased production to the point where Chinese manufacturers had a 90% share of the shipping container market by 2002 (Globalization Monitor, 2011) and about a 95% share of the market by 2015 (China Industry Information Network, 2017).

Table 2.3 Container Cargo Trade Imbalances for Each Interregional Route in 2017

Routes	Mainhaul (TEU)	Mainhaul from	Backhaul (TEU)	Imbalance (TEU)
FE-North America	18,607,823	FE	7,987,415	10,620,408
FE-Europe	15,816,578	FE	7,838,154	7,978,424
FE-IS and ME	7,532,426	FE	2,844,860	4,687,566
FE-South America	3,629,152	FE	1,802,003	1,827,149
FE-Sub-Saharan Africa	2,849,139	FE	1,183,911	1,665,228
Europe-North America	4,683,912	Europe	2,734,658	1,949,254
Europe-Sub-Saharan Africa	2,016,494	Europe	824,795	1,191,699
Europe-IS and ME	3,878,136	Europe	2,741,609	1,136,527
FE-Oceania	2,617,095	FE	1,609,699	1,007,396
North America-South America	2,879,082	North America	2,481,501	397,581
Others	6,986,622		4,705,954	2,280,668
Total for Inter-Regional Routes	71,496,459		36,754,559	34,741,900

Source: Container Trades Statistics

Even with bulk shipping, imbalances exist, but it is easier to address these imbalances because shipping companies or operators have more flexibility in the operation of bulk vessels than in the operation of container vessels (Stopford, 2009). However, there is a greater need to adhere to pre-determined schedules in container shipping, and thus it is more difficult to resolve imbalances[6].

[6] Of course, trade imbalances remain a problem in the bulk transportation system, and there are even cases where owners pay charterers to use their vessels. For example, Sand (2011) reported a negative freight rate stating that "On 13 January, the Baltic Exchange Capesize Route C11 from China/Japan to Europe was estimated at minus USD 229 per day. Since then the rates have worsened even further. At those rates, far below break-even OPEX levels, owners are literally paying charterers to carry their goods in order to reposition the vessel at the lowest possible expense."

Shipping companies are responsible for the shipping costs caused by these imbalances. In the voyage cash flow model created by Stopford (2009), assuming transpacific routes, the total repositioning cost was 2.9 to 4.1% of the navigation costs. Rodrigue (2017) estimated that repositioning costs paid by shipping companies amounted to about 16 billion USD or 15% of container management costs. Further, the Boston Consulting Group pointed out that 5–8% of the operating expenses of container carriers are repositioning expenses, and the burden on the shipping industry as a whole is 15–20 billion USD (Sanders *et al.*, 2016)[7,8].

Container shipping companies have tried to maintain tight control over their containers by reducing freetime and increasing retention fees[9]. In addition, they have attempted to optimize container logistics by unloading/loading in warehouses or distribution centers in the immediate hinterland of the relevant ports (Theofanis and Boile, 2009). However, many measures are unable to be improved significantly, and thus additional measures are necessary to reduce trade imbalances.

2.5 Bulk Cargo as Additional Container Cargo

Container shipping companies are suffering from a deterioration in market conditions as a result of shrinking container cargo margins and increased supply through more vessels and larger vessel sizes.

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[7] If the imbalance is substantial for shipping companies, they must operate dedicated vessels to bring empty containers back. For example, Theofanis and Boile (2009) stated that up to 19 vessels with a carrying capacity of 8,000 TEUs are required each week for empty repositioning from the US to overseas destinations.

[8] Containers are usually owned by container shipping companies and container leasing companies. According to the estimates of Triton International, the world’s largest container lessor, leasing companies owned slightly more than 50% of all containers in 2017. Further, it showed that the number of containers owned by leasing companies had nearly doubled since 2010, while the number owned by shipping companies has remained steady at around 20 million TEUs (Triton International, 2018).

[9] Freetime refers to the period container shipping companies allow to consignees or their representatives before returning the empty containers to the container depot. A retention fee is a charge by container shipping companies if the period of retention by the consignee exceeds the freetime.

As a result of increases in both the average size of ships and ship numbers, container ship capacity is growing faster than the amount of container cargo, resulting in excess supply of container shipping. Because there is no opportunity to increase existing types of container cargo, shipping companies and terminal operators need to find additional types of cargo if they are to increase their revenues. Rodrigue and Notteboom (2015) argue that it is crucial to develop niche markets and attract cargo that has not previously been transported by container.

Therefore, BCC, which involves the transport in containers of bulk cargo that has traditionally been carried by bulk carriers, is attracting increasing attention, and importers have begun to change to container shipping as their preferred transport mode for bulk cargo. However, this method is not new. In the 1980s, it was used as part of a shipping company's empty container return strategy from the US to Asia, and a grain transporter near the port of Los Angeles used containers to transport cereals as early as 1974. A well-known example of BCC is the transport of coffee beans, which began to be carried in containers in the 1980s, and are now almost exclusively transported by container (Stopford, 2009; Rodrigue and Notteboom, 2015). In Japan, BCC has been used in relation to hay since the 1980s and soybean imports since the 1990s.

BCC came to notice in the latter half of the 2000s after a sudden rise in bulk freight rates. The freight rates for dry bulk carriers rose dramatically because of an expansion in the gap between the supply of and demand for bulk carriers, while the freight rates for container vessels remained relatively stable. As a result, a relative cost advantage for containerization emerged, and importers shifted to container vessels for hauling bulk cargo. Theofanis and Boile (2009) pointed out that in 2008, imports of container cargo at PSW ports declined while exports increased partly as a result of the shift of some minor types of bulk cargo to containers. Mongelluzzo (2007) also pointed out that the increase in container use was derived mainly from a dramatic increase in the export of grains by container from the US. At the time, the capacity of bulk carriers was limited, and they were unable to handle the increased volume of grain. Meanwhile, container vessels had sufficient excess space to move this cargo along the westbound transpacific route from the US to East Asia.

The increase in the use of containers for bulk cargo exports from the US was also studied by Wilson and Benson (2009) using Waterborne Commerce data. According to their study, 11.7% of all international cargo from/to the US in 1990 made use of containers, in terms of tonnage. This figure increased to 19.5% in 2005.

Advances in technology are considered to have led to an increase in container shipping (Matsuda and Kawasaki, 2013; Clott *et al.*, 2015), especially in relation to BCC in the late 2000s. For example, in 2004, the US company Advanced Steel Recovery (ASR) invented prompt loading/unloading facilities for ferrous scrap transported by container vessels. ASR obtained a US patent for this system in 2007[10]. In 2009, A-WARD, a New Zealand company, obtained a US patent for a "container tilter," a cargo loader/unloader that works by tilting containers. These facilities allow for fast, efficient, and cost-effective loading and unloading of bulk materials transported by container.

Entities such as shipping companies and port managers expect BCC to provide new sources of cargo[11]. For example, if the average containerization rate of commodities that currently have a containerization rate of 1% to 90% increased by 3.0%, global containerized trade would rise by 8.9 million TEUs or 6.3%, while global dry bulk cargo trade would only fall by 1.5%[12]. Further, the need to improve the efficiency of container transportation is another reason BCC is receiving increased attention. As mentioned earlier, one reason for introducing BCC was the existence of an imbalance between mainhauling and backhauling. Thus, BCC had developed mainly in relation to backhauling (UNCTAD, 2013) in an attempt to increase container shipping companies' revenues by decreasing this imbalance. As a result, BCC is considered to be a practical solution to the problem of reducing repositioning costs (Rodrigue and Notteboom, 2009).

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[10] Seabrook (2008) explains the development of FASTek in detail.

[11] Iron ore and coal accounted for 41% of bulk cargo movements in 2017 (NYK Research Group, 2017). However, many practitioners do not consider these goods to be appropriate for containerization, although there are some exceptions such as Ukraine and China. Yang *et al.* (2016) outlines the Chinese practice of containerized transport of coal mined in Shanxi and Inner Mongolia.

[12] Author calculations based on IHS Markit's World Trade Service data.

2.6 Transportation Processes for Bulk Shipping and Container Shipping

Figure 2.3 shows a simplified diagram of bulk shipping and container shipping.

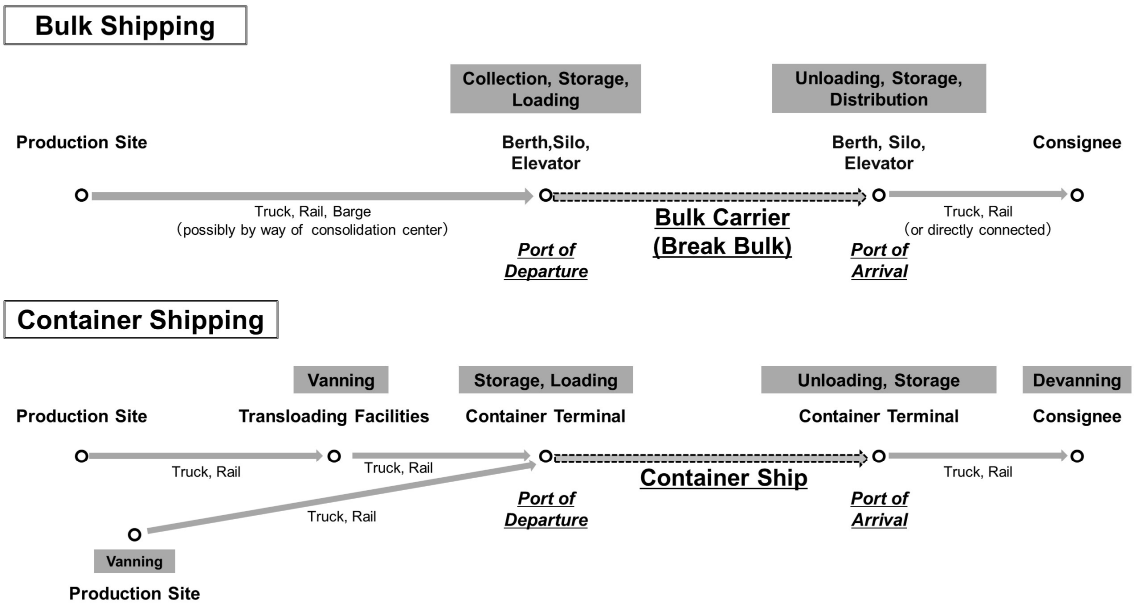

Figure 2.3 Bulk Shipping and Container Shipping Processes

In bulk shipping, producers carry cargo to conservation centers such as consolidation centers (see Figure 2.4), from where the cargo is transported to quayside storage areas by trucks, railcars, and barges. In the cases of cereals and chemical products, they are kept in dedicated facilities such as elevators and silos (see Figure 2.5) that enable storage of large quantities and play a role in cargo handling as well. Cranes or dockside facilities are used to load/unload bulk cargoes (see Figure 2.6 and Figure 2.7). Breakbulk vessels usually have cranes that can be used for loading and unloading. The cargo is placed on trucks or railcars at a quay or storage facility and transported to its final destination. Sometimes the elevator or silo is directly connected to the final destination.

Figure 2.4 Country Grain Elevator in Champaign County, Ohio

Source: Dual Freq,
https://commons.wikimedia.org/wiki/File:Rural_Champaign_County_grain_elevator.jpg

Figure 2.5 Grain Elevator in Vancouver

Source: United Grain Corporation

Figure 2.6 Bulk Carrier ”CAPE HAYATOMO”

Source: Kawasaki Kisen Kaisha, Ltd.

Figure 2.7 Workers Loading Imported Soybeans onto Trucks at a Port in Nantong in China
Source: Jiji Press Photo, Ltd

In container shipping, producers pack containers (hereafter termed "vanning") at the factory or production location or transport the cargo to the transshipment facility for vanning (see Figure 2.8). Vanning methods differ among various types of commodities. Some commodities such as scrap steel and hay are packed as is, while materials such as liner bags are occasionally used to contain granular commodities such as grains (see Figure 2.9). In the case of grains grown in the central areas of the US, the cargo may be vanned after being transported to the transit facility in California by rail (see Figure 2.10). Cargo that is transported by container ship (see Figure 2.11) is then removed from the containers at the final destination (hereafter termed "devanning").

Figure 2.8 Container Transloading Facility in Los Angeles

Figure 2.9 Malt Packed in a Container Using a Liner Bag

Source: Nippon Yusen Kaisha

Figure 2.10 Containers Hauled by Train at Long Beach, California

Source: Union Pacific Corporation

Figure 2.11 Container Ship **“**ONE COMMITMENT”

Source: Ocean Network Express Pte. Ltd

Because bulk transport enables commodities to be moved in large quantities, it is suitable for supply to large-scale markets. However, it is necessary to accumulate at least 1,000 tons of cargo to utilize bulk shipping[13]. Meanwhile, container shipping is more applicable to small-lot shipping[14]. Moreover, it operates at high frequency and with a short leadtime, so it is ideal for frequent shipments to markets of relatively small scale. In bulk transportation, grain that is produced by numerous farms is combined before being transported to the departure port and freighted as a single cargo. Conversely, container transportation enables shipments to remain separate after vanning, and thus is suitable for the transport of “identity preserved” cargo, thereby enabling various production locations and varieties to be identified.

[13] Even a load of 1,000 tons is insufficient to charter an entire ship. When shippers or consignees carry these types of cargo by bulk shipping, they lease an area in the hold of a bulk carrier.

[14] As indicated in Table 2.1, a 20-foot container can carry about 20 tons of cargo. However, container shipping is only viable if customers have sufficient cargo to fill a container. Therefore, forwarders offer less than container load (LCL) services, whereby they collect various cargoes that are headed for the same destination and combine them in a single container.

It is also worth noting that freight rates for container shipping are usually higher than those for bulk transport. In December 2017, the voyage contract fee for a handysize bulker carrying 28,000 tons of bulk cargo from the west coast of the US to Yokohama Port was 9,508 USD/day-ship, meaning a freight cost of 6.8 USD per ton (excluding cargo handling fees). Meanwhile, the rate for a 40-foot container was 678 USD (excluding terminal handling charges in Yokohama), or 27.1 USD per ton, nearly four times higher than the bulk shipping rate.

2.7 Current Status of BCC

2.7.1 Trends in Containerization

As noted above, containerization commenced in developed countries for the movement of general cargo. Since then, containerization has broadened its scope in terms of both commodities transported and geography. Figure 2.12 shows the current status and underlying trend in containerization using the containerization rate[15]. In addition, IMF classifications, which are based on *per capita* income, trade diversification, and the degree of integration into the global financial system[16], are used to categorize developed and developing countries.

The containerization rate in relation to global maritime trade was 8.6% in 1995, increased to 10.0% in 2000 and 13.0% in 2007, remained at 12–13% for several years, and was 13.2% in 2017. Containerization rates were higher in relation to exports from developed countries than those from developing countries. Containerization rates for export from developed countries either showed no significant change or declined, which supports the view of Rodrigue and

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[15] In this section, movement data released by IHS Markit's World Trade Analysis is used rather than the Clarkson data used in Figure 1.1. This is because although Clarkson data covers a longer period, it does not include origin and destination information.

[16] IMF sets (1) the *per capita* income level, (2) export diversification, and (3) the degree of integration into the global financial system as the main criteria used to classify the world into developed countries and developing countries. The nominal *per capita* GDP for developed and developing countries in 2017 is shown in Appendix I.

Notteboom (2015) that developed countries have reached the limit of containerization through conversion from general cargo. Containerization rates have remained at around 13–15% (14.8% in 2017) for trade between developed countries. Meanwhile, in relation to exports from developed countries to developing countries, containerization rates remained at around 20% prior to 2008, and then decreased until 2017. This decline was mainly the result of a surge in the export of bulk cargoes such as grains from the US to China.

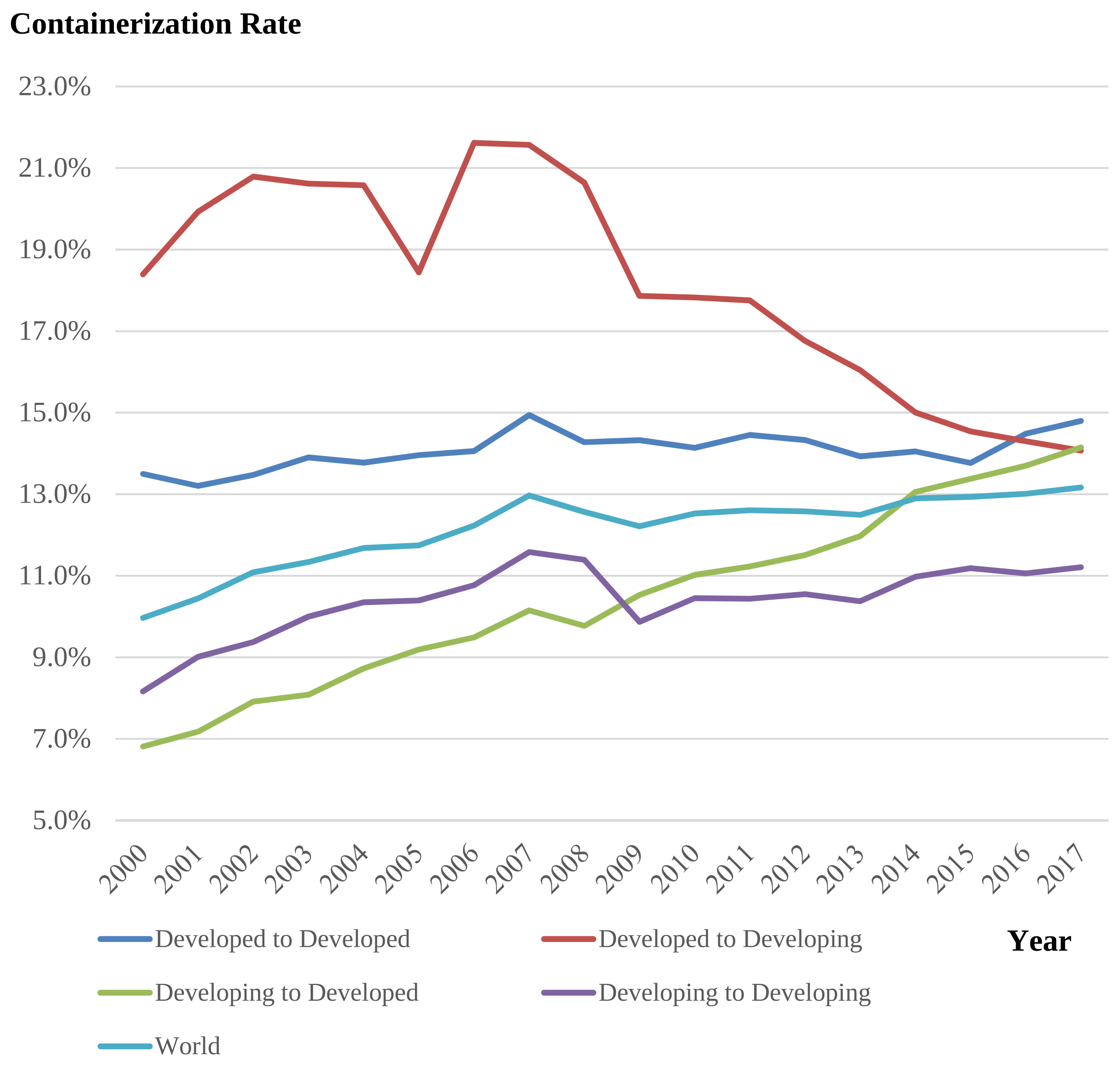


Figure 2.12 Containerization Rates from 2000 to 2017

Source: IHS Markit's World Trade Service

Note: Country categorization is based on the IMF's World Economic Outlook database.

The containerization rate for exports from developing countries to developed countries has continued to increase, rising from 6.8% in 2000 to 10.2% in 2007 and 14.1% in 2017. This reflects the continued growth of the manufacturing sector in developing countries such as China and members of the ASEAN. Changes in the containerization rate for trade between developing countries are similar to the overall global changes, with a slight increase in the first half of the 2000s, followed by a period of stagnation. The containerization rate increased from 8.2% in 2000 to 11.6% in 2007, before settling at 9–11% (11.2% in 2017). The surges in both containerized cargo such as manufactured goods and bulk cargo such as iron ore occurred at the same time, and thus the growth in the container trade volume was canceled out by the growth in the bulk shipping trade volume. Containerized cargo has increased by 84.0% over the last decade, while total bulk cargo has increased by 90.9% over the same period.

Looking at the shares of container cargo, trade between developed countries accounted for 29.0% of the world total in 2000, but this had almost halved to 14.8% by 2017, while the cargo volume only increased 1.2 times from the figure in 2000. Cargo from developed countries to developing countries accounted for 23.5% of the world total in 2000, and remained relatively unchanged in 2017 at 24.8%, although the volume increased 2.5 times. Trade from developing countries to developed countries accounted for 32.5% of the world total in 2000, but had decreased slightly to 30.0% by 2017, although the cargo volume increased 2.3 times. Trade among developing countries accounted for 15.0% of the world total in 2000, and had increased to 30.4% by 2017, with the cargo volume increasing 4.9 times.

2.7.2 Containerization by Commodity Group

In 2000, the number of commodities for which the containerization rate was greater than 80% was 85 out of the 202 commodities classified by IHS Markit based on the ISIC system. In 2007, this number was increased to 102 and further it was 115 in 2017. Figure 2.13 shows the containerization rates by commodity over the last decade and the average growth rate between 2000–2007 and 2008–2017.

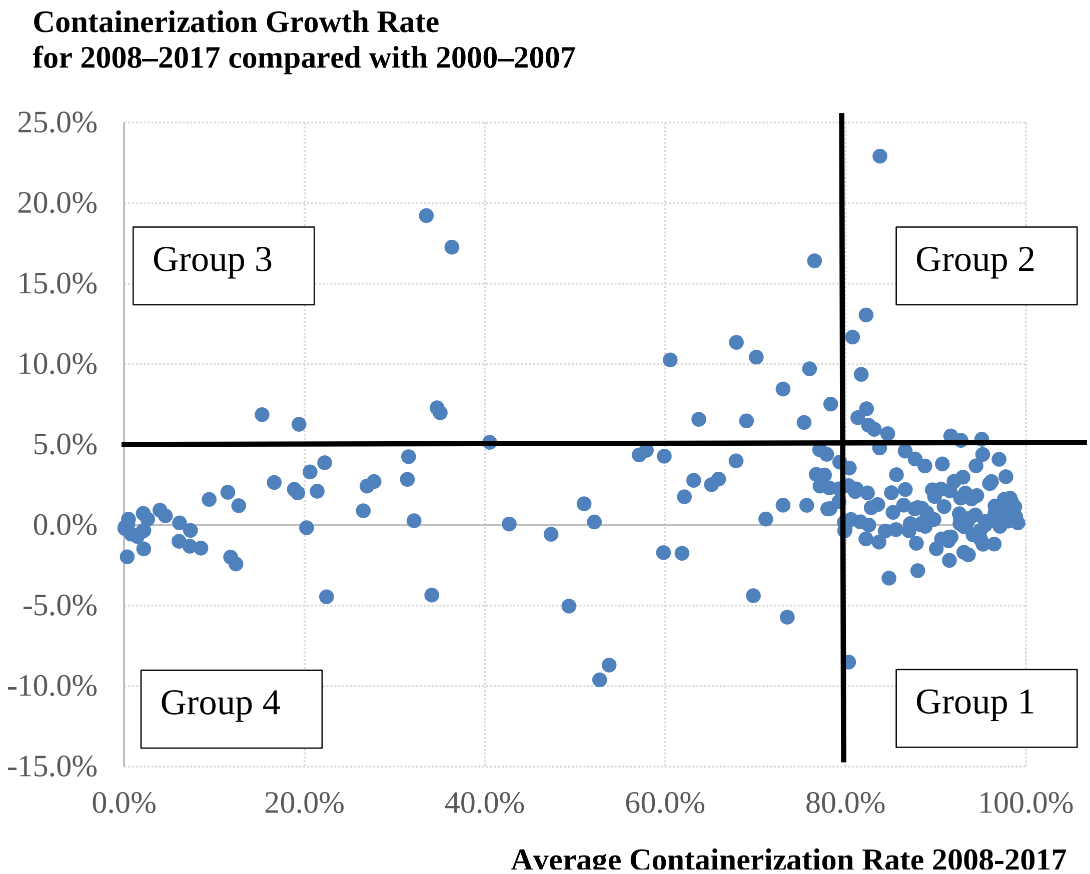


Figure 2.13 Average Containerization Rate for Each Commodity over the Period 2008–2017 and Growth Rate Compared with that for the Period 2000–2007

Source: IHS Markit's World Trade Service

For the purposes of this study, commodities have been divided into four areas based on containerization rates during the period 2008–2017 and the average growth in containerization rates between 2000–2007 and 2008–2017. The first group (group 1 in Figure 2.13) contains 97 commodities (out of a total of 201 commodities) with an average containerization rate of more than 80% and less than 5% growth. This group mainly includes commodities such as machinery, electrical appliances, foodstuffs such as fruit, and apparel.

An example of an item in group 1 is "Plastics in Primary Forms and Synthetic Rubber." The average containerization rate for this item was 80.4% during the period 2008–2017, but this had declined from an average of 88.9% for the period 2000–2007. The surge in Chinese bulk imports from Singapore and ME countries, and an increase in Indian, Indonesian, and Vietnamese bulk imports from China, Singapore, and Japan contributed to the decrease in the average containerization rate.

The second group had an average containerization rate of more than 80% and more than 5% growth. This group contains 12 commodities that mainly include foods, flowers, and building materials, as well as “Optical and Measuring Equipment, Meters and Counters,” a form of precision machinery. Group 2 also includes “Jams, Jellies, and Honey.” The average containerization rate for this item was 83.8% for the period 2008–2017, which was an increase from the average rate of 59.5% for the period 2000–2007. Containerization of these products increased worldwide in the first half of the 2000s, and the continuation of this trend contributed to the increase in the average containerization rate.

The third group had an average containerization rate of 80% or less and more than 5% growth. This group contains 17 commodities that mainly include food ingredients, building materials, and some raw materials. For example, Group 3 contains “Chicken and Turkey Meat, Frozen.” The average containerization rate for this item was 63.7% for the period 2008–2017, which was an increase from the average rate of 57.2% for the period 2000–2007.

Here, it is worth noting that a decline in demand is likely to increase the containerization rate. An example of this is the item “Meat and Fish Products, Not for Human Consumption; Dog and Cat Food, etc.” in Group 3. The average containerization rate for this item was 35.1% for the period 2008–2017, which was an increase from the average rate of 28.1% for the period 2000–2007. However, some of the increase was likely caused by a decrease in demand. In Japan, imports fell by 1.1 million tons or 46.8% between 2001 and 2017, while the containerization rate for Japanese imports rose from 33.2% to 43.0% during the same period. The reduction in Japanese imports was probably a significant factor in the increase in the average containerization rate.

The fourth group had an average containerization rate of 80% or less and less than 5% growth. This group contains 75 commodities that mainly include larger machines, food ingredients, recycling materials, building materials which are less processed, and some raw materials. For example, Group 4 includes “Chicken and Turkey Meat, Fresh or Chilled.” The average containerization rate for this item was 53.8% for the period 2008–2017, which was a decrease from the average rate of 62.7% for the period 2000–2007.

2.7.3 Containerization and the Value of Commodities

Figure 2.14 shows the relationship between commodity unit values (USD per kilogram) and containerization rates in 2017. This relationship is not linear, and the correlation coefficient between commodity unit values and containerization rates is 0.07. Meanwhile, the correlation coefficient between the natural logarithm of commodity unit values and containerization rates is 0.61.

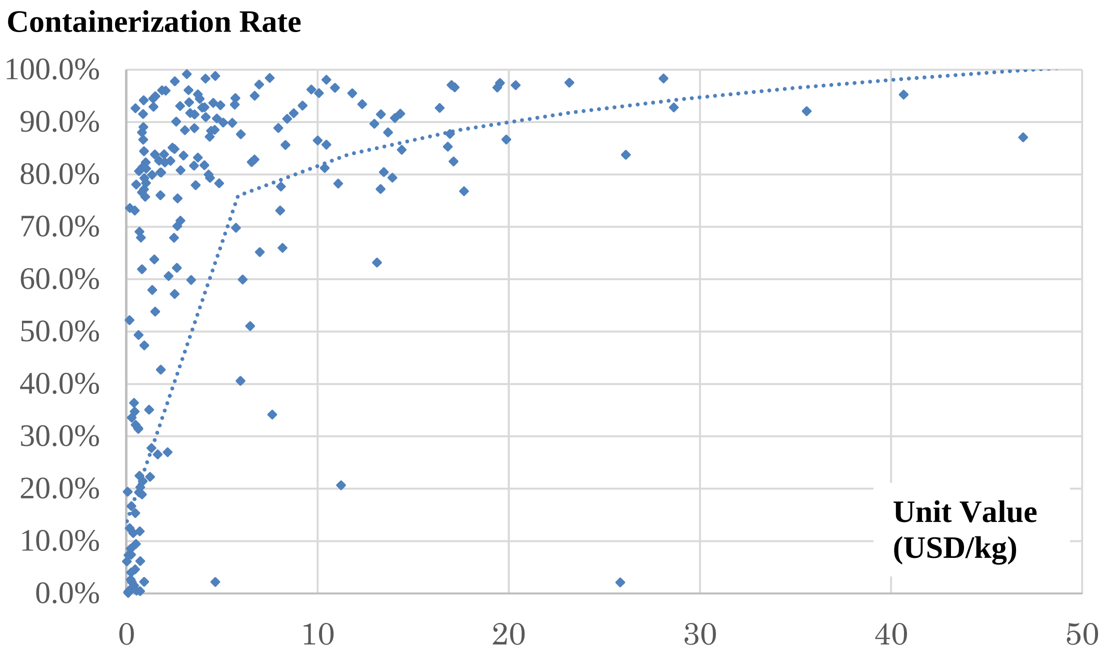


Figure 2.14 Relationship between Commodity Unit Values and Containerization Rates in 2017

Source: IHS Markit’s World Trade Service

Note: The dotted line indicates the approximated curve.

As can be seen from Figure 2.14, containerization rates for low-value commodities or goods (including some types of bulk cargo) tend to be low, but increase rapidly in response to a slight increase in commodity unit value. With some exceptions such as trains and trailers[17], cargo seems to be almost fully containerized if the unit value is more than 5 USD per kilogram.

Table 2.4 Commodity Unit Values and Average Containerization Rates in 2017

	USD per kilogram						
	Below $2	$2-4	$4-6	$6-10	$10-15	$15-20	Above $20
Average Containerization Rate	46.1%	81.3%	82.3%	79.4%	83.4%	89.9%	86.6%
Number of Commodities	80	32	22	18	20	10	19

Source: IHS Markit's World Trade Service

Table 2.4 shows the average containerization rates for various unit values. As can be seen, the average containerization rate for commodities with a unit value of less than 2 USD per kilogram is 46.1%, while for commodities with a unit value of between 2 USD and 4 USD per kilogram, the average containerization rates increase significantly to 81.3%. However, the average containerization rates are not significantly higher for commodities with even higher unit values.

2.7.4 Containerization and Trade Routes

Although, as noted earlier, the overall rise in containerization has stagnated in recent years, the situation differs across various trade routes. In 2000, containerization rates varied from 0.8% (ME to FE) to 67.6% (IS to CAC) (see Table 2.5), but by 2017, containerization rates had increased along almost all trade routes, varying from 1.5% (Oceania to South America) to 68.7% (FE to North America) (see Table 2.6). Cargo tends to be more containerized if

[17] Shipping companies normally use pure car carriers or general cargo ships to carry these types of cargo.

more manufactured goods are shipped, whereas containerization rates are likely to be lower if raw materials for energy production such as coal and crude oil are transported.

Table 2.5 Containerization Rates between Various Areas in 2000

	Africa	CAC	FE	EU	IS	North America	Oceania	South America	ME	World Total
Africa	10.1%	5.9%	3.8%	3.8%	2.0%	1.9%	7.2%	2.1%	4.1%	3.6%
CAC	17.9%	13.3%	13.0%	42.2%	38.2%	14.3%	9.8%	10.4%	16.5%	18.1%
FE	26.7%	35.8%	19.3%	43.1%	12.0%	46.6%	14.0%	35.8%	39.9%	24.6%
EU	23.7%	33.0%	40.5%	n.a.	21.9%	22.3%	58.3%	34.5%	28.7%	24.8%
IS	32.7%	67.6%	6.4%	34.6%	19.7%	54.8%	20.7%	11.1%	27.3%	15.7%
North America	6.8%	16.0%	21.1%	13.3%	23.2%	2.1%	27.3%	18.3%	11.2%	12.4%
Oceania	9.8%	40.0%	2.6%	3.5%	3.5%	17.4%	14.8%	1.6%	5.6%	3.5%
South America	6.1%	2.7%	4.7%	6.6%	3.1%	6.8%	28.8%	14.6%	5.4%	6.6%
ME	3.0%	29.9%	0.8%	3.2%	3.2%	2.5%	2.4%	1.3%	16.2%	2.0%
World Total	12.7%	8.1%	10.1%	9.8%	5.0%	11.1%	16.2%	14.8%	15.6%	10.0%

Source: IHS Markit's World Trade Service

Table 2.6 Containerization Rates between Various Areas in 2017

2017	Africa	CAC	FE	EU	IS	North America	Oceania	South America	ME	World Total
Africa	12.7%	8.8%	3.2%	7.2%	3.1%	5.2%	2.7%	3.8%	15.6%	5.9%
CAC	22.1%	32.1%	22.9%	45.3%	13.7%	25.3%	28.1%	20.5%	39.9%	28.2%
FE	37.1%	31.8%	22.8%	67.7%	12.6%	68.7%	23.4%	48.5%	49.2%	30.3%
EU	19.6%	42.1%	45.5%	n.a.	24.3%	39.3%	63.4%	34.6%	28.7%	31.8%
IS	20.6%	56.2%	10.3%	29.4%	15.5%	57.0%	16.2%	35.3%	20.5%	20.6%
North America	14.0%	14.9%	23.0%	11.9%	17.2%	2.7%	34.6%	11.8%	22.9%	15.2%
Oceania	18.7%	67.8%	1.2%	8.6%	2.9%	32.7%	29.2%	1.5%	8.8%	1.9%
South America	10.0%	9.0%	2.8%	7.6%	2.9%	11.7%	15.3%	16.1%	6.4%	6.3%
ME	12.7%	31.7%	2.4%	6.2%	2.5%	5.5%	7.9%	8.8%	21.8%	4.4%
World Total	18.4%	17.5%	9.8%	17.2%	7.6%	23.4%	23.3%	18.6%	22.7%	13.2%

Source: IHS Markit's World Trade Service

In addition, it is worth noting that the containerization rate for each route is not symmetric. For example, in 2017, the containerization rate for the route from FE to North America was 68.7%, while it was 23.0% in the opposite direction. This suggests that there is an opportunity for increased containerization to alleviate trade imbalances to some extent.

2.8 Benefits of BCC

When a shift is made to BCC, shippers/consignees usually form a new contract with another shipping company because most shipping companies are dedicated to either bulk shipping or container shipping operations, and few provide both services. In the case of bulk transport, the shipping contract may be via a trading company or a broker, but in many cases the shipping company and shipper/consignee form a direct contract, while in the case of container shipping, shippers/consignees are more likely to delegate this role to their forwarders[18]. Thus, a container shipping contract is more akin to an air cargo contract than a bulk shipping contract.

It is also worth noting the different frequencies of bulk transport and container transport. Bulk shipping carries a large amount of cargo in one shipment that is then used over a relatively long period. Therefore, the frequency of bulk shipping between the same OD by the same shipper/consignee is not high. However, it is hard for shippers and consignees to switch from container shipping back to bulk shipping in the middle of a fiscal year or planning period because the volume required to be carried by bulk shipping is usually larger than the volume shipped by consignees in the given fiscal year or planned period. That is, once a transport mode has been selected, customers must commit to using that mode for a specified period. Customers can use bulk shipping and container shipping in combination, but the ratio cannot be changed during the specified period. This means that if customers choose container shipping, their cargo will be carried in small units for the duration of the contract period.

[18] Direct contracts with container shipping companies are also used. However, this mainly applies to large customers.

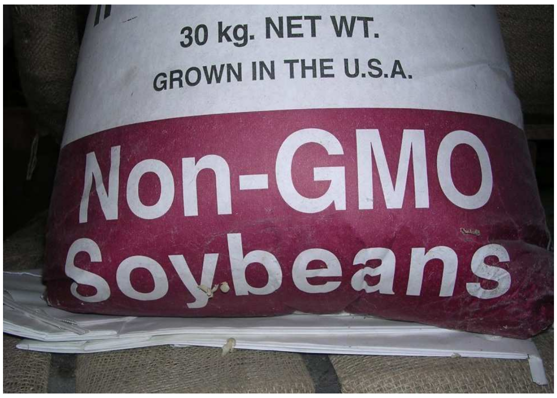
Regarding the development of BCC, shippers/consignees have come to recognize the advantages inherent in container shipping, such as higher frequency and smaller lot sizes compared with bulk cargo shipping (Ishihara and Goda, 2010; Mongelluzzo, 2007). For instance, the management of individual cargo lots is relatively simple[19] (Clott *et al.*, 2015; Rodrigue and Notteboom, 2015). In addition, the cost per trade is relatively low when container shipping is used (Mongelluzzo, 2007). In particular, container shipping is an advantageous transport mode for smaller shippers/consignees, and can reduce the risk of surplus inventory and price volatility (Mongelluzzo, 2007). The volume per bulk carrier shipment is much larger than that for container shipping, therefore bulk carriers enable the transportation of larger volumes of cargo. Economies of scale suggest that the unit price of goods shipped in bulk would be lower. However, bulk shipping also poses greater risks for shippers/consignees, as noted above.

Moreover, the leadtime for container shipping tends to be shorter than that for bulk shipping (Rodrigue and Notteboom, 2015; Mongelluzzo, 2007), and thus the consequent earlier settlement is another advantage of using container shipping (Mongelluzzo, 2007).

BCC also offers benefits to consumers. Some consignees, especially in developing countries, only need small amounts of bulk cargo, thus if they want to use bulk shipping, various factors may prevent them from importing the cargo they require. For example, bulk carriers tend to be large, and if they cannot enter a port near the consignee, or the consignee does not have sufficient storage space or facilities to receive a significant amount of cargo that will result in high levels of inventory, they will be unable to obtain the cargo they require. Hence, container shipping, which enables smaller amounts to be consigned, is more suitable for these consignees.

[19] Traceability is also a benefit of container shipping. Clott *et al.* (2015) pointed out that shippers and importers increased their use of container haulage because of its traceability. Nishi (2008) used the example of a Japanese importer who used container shipping for the import of edible soybeans to prevent them from being mixed with GMO soybeans.

Some consignees, mainly in developed countries, require identity qualified bulk cargo (e.g., non-GMO soybeans and stamping steel) because they have a particular interest in safety or quality, even though the cost is higher than that of bulk shipping. If they use bulk shipping, there is a possibility of their product being contaminated by non-qualified cargo like GMOs. Container shipping enables consignees to preserve the integrity of their consignment.



Non-GMO Soybeans

Steel Scrap from Automobile Factories

Figure 2.15 Examples of Identity Qualified Bulk Cargo

Source: The Organic & Non-GMO Report, Taiho Industry Co.,Ltd.

A practitioner advised that BCC of soybeans was instigated by natto producers who were uncompromising regarding the quality of the ingredients they used[20]. In Taiwan, BCC progressed in relation to scrap iron and agricultural imports in the latter half of the 2000s (Matsuda and Kawasaki, 2013; Lirn and Wong, 2013). Even within East Asia, including Southeast Asia, BCC is progressing in the 21st century through the transport of goods including building materials, recycled products, food, clothing, steel, and aluminum.

Another benefit of BCC is also related to smaller shipment sizes. BCC makes it possible to transport a small initial amount as an experiment when it is not yet known what the level of demand for the product will be. Container transport is sometimes used for such purposes as sending experimental shipments of grain and the like to developing countries and transporting an initial supply of raw materials for factory start-ups. Container transport can

[20] See Nishi (2008) for details regarding the containerization of soybean imports into Japan.

also offer a more efficient transportation mode when an economy contracts and demand is reduced. Many studies have argued that the transport mode should be chosen in response to the stage of the product cycle (e.g., Murakami and Matsuse, 2014). Container shipping is an efficient way to transport small volumes at both the initial and closing stages of the product cycle.

2.9 Chapter Conclusion

This chapter has outlined the current status of BCC. First, the progress of containerization, including periods of diffusion and stagnation, was reviewed. Then, problems inherent in container shipping, namely trade imbalances and repositioning, were outlined. Next, BCC was introduced as a solution to the problems of stagnation of containerization and trade imbalances. Finally, the characteristics of container shipping and bulk shipping were illustrated, along with the current status and benefits of BCC.

In developed countries, the trend toward containerization has not changed significantly since the beginning of the 21st century, as reported by Rodrigue and Notteboom (2015). In addition, since the latter half of the 2000s, bulk transport from developed countries to developing countries has increased, leading to a sharp decline in the containerization rate. Meanwhile, the containerization rate for trade from developing countries to developed countries continues to rise. Although container cargo trade is increasing among developing countries, bulk cargo trade is also increasing, and thus the containerization rate has not changed significantly since the late 2000s.

Looking at the status of containerization by category of goods, the group that has a high average containerization rate but no significant growth over the last decade includes goods such as machinery, electrical equipment, fruit, and apparel. This group may have experienced a decline in the containerization rate as a result of an increase in bulk transport. The group of goods with both a high average containerization rate and significant growth includes precision machinery, food, and flowers. Containerization of these items has progressed since the early 2000s, and is continuing to grow. The group of goods with a low average containerization rate but significant growth includes food ingredients, some building materials, and some raw materials. One reason for the increase in the average containerization rate of these goods is a reduction in transportation volumes as a result of a decline in demand. The final group of goods has a low average containerization rate and low growth, and includes recycling products and some raw materials.

The relationship between the unit value of the commodity and the containerization rate is not linear. The containerization rate increases sharply when the unit value rises to between 2 USD and 4 USD per kilogram, but there is no significant difference in containerization rates at higher unit values. Looking at containerization rates by route, the rates tend to be higher on routes where manufactured products are carried, and lower on routes where large amounts of raw materials for energy production are transported. Further, the containerization rates for various routes are not symmetric, confirming the significant imbalances that exist in relation to containerized transport.

The benefits of BCC include shipping to small or medium-sized consignees, risk avoidance in response to changes in demand, inventory reduction, and shorter leadtimes, enabling shippers of bulk goods to make full use of the advantages of small-lot transport by containers. From these results, it seems that trade using BCC is focused on imbalanced routes from developed countries to developing countries. It is crucial to acquire items that do not have a high containerization rate at present such as raw materials, food ingredients, building materials, and recycled products. In addition to the transportation of new types of goods, the benefits of BCC are expected to be demonstrated in transportation not only to areas where demand is expected to increase in the future but also to areas where demand has decreased.

Thus, BCC may provide new business for container shipping. As mentioned in Section 2.5, if the transportation mode for commodities shifts toward container shipping, global containerized trade will rise significantly, while dry bulk cargo trade will only fall by a relatively small amount.

CHAPTER 3

REVIEW OF PREVIOUS STUDIES

3.1 Introduction

This chapter provides a review of the literature that is considered relevant to this dissertation. First, studies on the progress of containerization are presented, followed by the literature on the stagnation of containerization in recent years. Studies on imbalances in containerized transportation are also reviewed because this is a significant factor in the promotion of BCC. Then, studies of BCC and transport mode selection are reviewed. Finally, conclusions regarding the direction of future research are presented.

3.2 Literature on the Progress of Containerization

As noted previously, containerization is regarded as a means of promoting international trade. Levinsohn (2006) presented a comprehensive history of containerization and highlighted the reduction in trade costs that it facilitated. Hummels (2007) used five-digit SITC codes to analyze a sample of commodities imported to the US from 1974 to 2004 to determine patterns in international marine and air transportation costs, and found that the *ad valorem* cost was significantly reduced when exporting countries and goods were controlled for. It was found that when the share of containerized cargo doubled, the associated transportation costs only increased by 13.4%.

These reductions in transportation costs as a result of containerization encouraged an increase in international trade. Bernhofen *et al.* (2016) examined the trade promotion effect using an econometric model covering the period of container adoption and showed that containerization has been one driver of the globalization of the economy in the second half of the 20th century. First, they defined containerization adoption as the point at which the handling of containers at port or rail terminals commenced. In addition, they regarded containerization as a technology specific to various pairs of exporting and importing countries, which were represented by a dummy variable. They analyzed data from 157 countries for the period from 1962 to 1990, and then divided this period into three sub-periods. The first sub-period was from 1962 to 1965, when there was no diffusion of containerization, the second was from 1966 to 1983, when containerized transport was introduced all over the world, and the third was from 1984 to 1990, when no new countries introduced containerized transport. Their analysis was based on four-digit SITC codes and examined whether the introduction of containerized transport had a positive impact on the amount of trade and whether the future containerization of new products would have a positive impact on the amount of trade. Their results showed that containerization has had a significant influence on the growth of bilateral trade, and in some cases the impact was still being felt 15 years later. Further, their estimation results showed not only the stimulation effects of increasing the amount of trade for containerizable products such as automobile parts but also the complementary effects for non-containerizable products such as automobiles .

Other studies have conducted more sophisticated structural analyses to examine the impact of containerization. Cosar and Demir (2017) analyzed the impact of containerization on shipping costs. First, they analyzed a trade model based on monopolistic competition involving companies that produced heterogeneous goods. Container transport costs include higher fixed costs than general cargo transport costs, but the additional costs as a result of increased transport distances are relatively low. Therefore, cargo that is to be shipped over long distances is better suited to container shipping than general cargo shipping. Based on this, they used an econometric model to analyze data on exports from Turkey in 2013. It was found that companies with higher productivity considered that the use of container transportation increased profitability. Further, the cost of the first mile of container transportation is 1.27 times that of general cargo transportation, but the cost elasticity in relation to distance is lower for container transportation. Therefore, the difference in transportation costs between general cargo transport and container transportation tends to fall as the distance increases. Moreover, they found that transportation costs were lower for container transportation over distances of more than 103 kilometers. For example, the costs for the journey between China and the US were 22% lower using container transportation. In addition, they showed that trade values fell by around 30% for average-distance trade partners if containers were not used, and that this figure increased to 40% for long-distance trade partners. However, the increase in trade volume as a result of the development of containerization was not significant because less productive companies were able to engage in trade as a result of the development of containerization, and these companies did not add significantly to the overall value of trade.

Regarding the development of containerization, Guerrero and Rodrigue (2012) used hierarchical cluster analysis and divided the evolution of the global container port system into seven classes representing five long waves, each of which corresponded to a stage in the development of containerization.

Rua (2014) analyzed the adoption and diffusion of containerization using microeconomic and econometric modelling. She first analyzed the choice of transportation mode between container and general cargo ships by firms and choices by governments concerning the introduction of container ports using a monopolistic competition model, basing her analyses on the following premises. First, a container ship is faster and the leadtime is shorter, so the cost per unit of freight is lower for container shipping. Second, the cost of introducing container transportation is higher because it is necessary to introduce a more sophisticated logistics system. Third, the cost of introduction is falling year by year. Under these assumptions, she used econometric models and country-level data regarding containerization from 1956 to 2008 and obtained the following results. (i) Companies with high productivity choose containerization as the cargo transportation mode because the growth in income from exports means that the fixed costs per unit are reduced. (ii) As the fixed costs gradually decline, even firms with low productivity will be able to make increasing use of containerization. (iii) As the container transportation network grows, the share of container shipping will rise. (iv) If governments expect that container usage will grow substantially, the introduction of container ports will proceed.

Rodrigue and Notteboom (2009) outlined the potential of containerization, stating that the container is “much more than a box; it is a vector of production and distribution,” after examining the changes over the half century since container transportation was introduced. They pointed out that although the introduction of new modes of transport took time, it was not only the introduction of a new transportation method but also changes in production methods, maritime logistics, inland logistics, and consumption through intermodal transport that needed to be considered. They also noted the potential use of container transportation at almost all stages of the supply and commodity chain, and anywhere where adequate transport infrastructure has been developed.

3.3 Literature on the Recent Stagnation of Containerization

Containerization progressed in the first half of the 2000s, but then stagnated, as explained in Chapter 2. Fenton *et al.* (2018) interviewed 30 leaders and experts in shipping-related industries seeking their comments regarding the recent stagnation of containerization. They explained that "Fundamentally, this is because many commodities have fully containerised already." In addition, they stated that "the future of containerisation then will be decided by how 'mid-containerised' commodities evolve."

From the academic perspective, Rodrigue and Notteboom (2015) reached essentially the same conclusions as Fenton *et al.* (2018). Based on the premise that recent developments in containerization have occurred in stages, they outlined the progress of containerization as follows: (1) change in transport mode from general cargo, (2) low freight rates offered for imbalanced routes (backhauling), (3) increases in transshipments, and (4) trade expansion through economic growth. Conversely, they noted that in recent years, (4) growth through economic expansion is becoming less dynamic, (1) substitution had been almost completed, especially in developed economies, and (2) the share of empty containers is relatively stable. Hence, they insisted that (3) growth through increased transshipments, and the development of niche markets and new opportunities are necessary to expand containerization. They proposed the containerized transport of goods in the commodity sector such as minerals and grains (i.e., BCC), as well as the transport of refrigerated products such as frozen foods.

3.4 Literature on the Effect of Trade Imbalances

In addition to the need to find new types of cargo, the need to improve the efficiency of container shipping is another reason to focus on BCC. As shown in Chapter 2, there are significant imbalances in cargo volumes between mainhaul and backhaul transport on many container trade routes, these imbalances being so large in many cases that shipping companies are sending numerous empty containers back to Asia (Stopford, 2009; Notteboom, 2012).

Theofanis and Boile (2009) examined global empty container logistics and analyzed the empty container management problem. They found that the reason for the surge in container trade imbalances was the change in the global production network since the 1990s, and pointed out that although repositioning involves additional costs, it is necessary to balance demand and supply. Then, they classified the players involved in the empty container logistics industry, that is, container shipping companies and container leasing companies. In addition, they explained the multilayered structure of the empty container management industry at the global, interregional, regional, and local levels. Finally, they introduced various studies aimed at alleviating the problem and presented some sophisticated, technology-based optimization strategies. However, many of the advanced solutions have been unsuccessful because container shipping companies are reluctant to share sensitive commercial information.

In the literature on international economics, the trade imbalance problem is sometimes referred to as the "backhaul problem." Ishikawa and Tarui (2017) explained the problem using a theoretical model. A shipping company conducts its operations so that the backhaul problem is minimized. However, when import tariffs and quotas are imposed, there is a possibility that the volume of imports needs to be reduced, and thus to avoid an increase in the backhaul problem, both the import volume and the export volume must be reduced. In other words, the presence of an imbalance may serve to prevent an increase in the trade volume.

3.5 Literature on the Benefits of BCC

BCC has been proposed as an effective way to reduce repositioning costs (Rodrigue and Notteboom, 2015). Indeed, BCC mainly occurs in relation to backhauling (UNCTAD, 2013).

In relation to Asia–North America trade routes, BCC has mostly developed in westbound trade (i.e., from North America to Asia).

Prentice and Craven (1980) conducted an early study of BCC and outlined its economic potential. Other early studies were mainly focused on the export of grains from North America (Prentice and Craven, 1980; Vachal *et al.*, 2003; Prentice and Hemmes, 2015). This reflects the fact that practitioners have focused on trade imbalances in the FE and North America since the early years of containerization.

Nita *et al.* (2008) estimated the containerization rates from/to the US, excluding trade with Japan, using the Port Import/Export Reporting Service (PIERS) database. They found that the containerization rate in Asia–US trade increased by 8.3% in movements from Asia to the US and 21.5% in movements from the US to Asia between 1997 and 2007, and concluded that BCC had contributed to the greater increase in volume from the US to Asia. They found a positive correlation between the rise in the containerization rate and the increase in container cargo volume from the US to Asia (excluding Japan), but could find no such correlation for trade from the US to Japan.

Some researchers have addressed the environmental issues relating to BCC. Suzuki and Kurokawa (2013) examined levels of CO_2 emissions in relation to the wheat trade from Vancouver to Busan and found that containerization could reduce CO_2 emissions by about 21%. Akakura *et al.* (2009) also found that CO_2 emissions could be reduced by improving the containerization rate in trade from North America to Asia.

3.6 Factors Affecting the Choice of Transportation Mode

In addition to the studies of Rua (2014) and Cosar and Demir (2018) pointing out that the productivity of exporters is a factor in choosing containerization, other studies have developed quantitative models regarding BCC. Matsuda and Kawasaki (2013) and Kawasaki and Matsuda (2014) analyzed shippers' choices between bulk shipping and container shipping in relation to trade routes from the US to Asia. The former analyzed ferrous scrap trade from the US to Korea and Taiwan, while the latter analyzed wood pulp trade from the US to Japan, Korea, and China. They both developed logit models in which choice was the dependent variable and freight rates, commodity prices, port of loading, and other economic factors were explanatory variables. The results showed that the progress of BCC differed depending on the importing country. They also showed that the most important explanatory variable was port of loading, as the choice of freight mode was heavily reliant on where the port of loading was located.

Clott *et al.* (2015) used an optimization model to determine where soybeans harvested around Illinois should be exported from. They proposed three alternative routes; shipping by barge down the Mississippi River to New Orleans, rail transport to Norfolk, or rail transport to Los Angeles. Regarding the option involving barges down the Mississippi River, they considered the possibility of congestion as a result of problems with locks. Xiang *et al.* (2017) used the Geospatial Intermodal Freight Transportation model to analyze the optimal network design for US soybean exports, and concluded that shipping by barge to New Orleans was the cheapest route for many areas in the Midwest and along the Mississippi River corridor. They also recommended increased investment in infrastructure along the Mississippi River and at the New Orleans port facilities to generate significant reductions in transportation costs.

Lirn and Wong (2013) analyzed choices between bulk cargo transportation and container transportation by Taiwanese grain shippers and importers. They distributed questionnaires to 26 Taiwanese shippers and used the fuzzy analytic hierarchy process to analyze the responses. They divided 12 criteria into three groups (total cost, control of cargo and quality, and service provided by shipping companies) to identify the factors that influenced the choice of transport mode, and found that total cost was the most important factor. They also showed that the most influential criterion among the 12 criteria examined was the difference in the price of grain between exporting and importing countries, followed, in order, by inventory cost, transportation cost, and in-transit inventory cost. These four criteria all belonged to the total cost group. In addition, they showed that grain importers or shippers exhibited a slight preference for bulk shipping rather than container shipping when markets were stable. Their study provides considerable insight for this dissertation because they focused on the choice between bulk shipping and container shipping.

BCC is one possible choice in terms of transport mode. In the transport mode selection model, the influences of freight, non-freight charges, and cargo characteristics are often taken into consideration. For example, Miyashita (2002) considers opportunity costs attributable to fares, inventory costs, product cycle changes, and logistics response capability in the selection of either air transport or container transport. Tsuboi *et al.* (2010) considered the choice between container shipping and air transportation using a model that took time, cost, inventory cost, and obsolescence cost into account. Murakami and Matsuse (2015) showed that products that are at peak valuation tend to be transported by air, while they are transported by container shipping when they reach the point of maturity in the product cycle. They investigated how shippers' choices reflect the product life cycle of commodities. Using structural equation modelling, they found that the product life cycle of cargo exported from Japan was perfectly correlated with the upward and downward movements in the air transport ratio.

3.7 Chapter Conclusion

BCC is a new form of containerization, and thus is a new transport mode that shippers can select. Thus, clarification of the mechanism underlying BCC contributes to the literature by providing new knowledge relating to containerization and transport mode selection. Therefore, previous studies on containerization, including the recent stagnation and trade imbalance issues, as well as studies on transport mode selection were reviewed in this chapter.

Previous studies on containerization have tended to focus on trends in containerization in relation to economic development and its influence on international trade. However, few studies have addressed the mechanism underlying containerization, in particular, the mechanism in recent years. These studies have not addressed macroeconomic aspects such as the status of various economies and their infrastructure. In addition, studies focusing on maritime affairs or maritime economics have tended to concentrate on descriptive analysis, and thus more quantitative analysis should be undertaken using appropriate models.

Therefore, to derive the mechanism underlying BCC, this dissertation examines both macroeconomic and microeconomic aspects. That is, the impact of economic conditions and infrastructure levels, decision-making entities regarding BCC, the relationships between those entities, and the structure of the decision-making process are all considered. This provides a meaningful contribution to the literature regarding maritime economics and logistics studies because it clarifies the mechanism underlying containerization as it enters a new stage.

This dissertation also contributes to the literature regarding transport mode choices. As mentioned in Chapter 2, prior research on mode selection in relation to international transport has mainly focused on the choice between container shipping and air cargo transport because of similarities in the types of goods that have traditionally been transported using these modes. However, there has been a lack of research on the factors influencing the choice between bulk shipping and container shipping.

Many practitioners including shipping companies, shippers, and consignees are now confronting the changing trend in containerization. This dissertation provides a meaningful reference in relation to the sourcing of new types of cargo and the selection of the most efficient cargo transport mode.

CHAPTER 4

ECONOMETRIC ANALYSIS OF BULK CARGO CONTAINERIZATION IN EAST ASIA

4.1 Introduction

In this chapter, factors related to BCC in East Asia (Japan, Korea, China, Taiwan, Hong Kong, Malaysia, Singapore, Thailand, Vietnam, Indonesia, and the Philippines) are examined using cluster analysis and simultaneous equation modeling. First, trends in the containerization rate in relation to various goods are identified using cluster analysis. Then, the determinants of the containerization rate are identified using simultaneous equation modeling. In the model estimation, characteristics are classified into clusters.

The first reason for choosing East Asia is that the volume of short sea container shipping is significant in this region. The second reason is the diversity in the region in terms of economic development and trade. This enables us to understand the relationship between economic development and containerization. The third reason is that container port development is progressing in East Asia, and thus it is possible to understand the relationship between containerization and container port development.

The promotion of BCC will result in an increase in the volume of cargo handled by container shipping companies. Currently, the volume of cargo transported by container in East Asia exceeds that along the transpacific and FE–Europe routes. As new cargo types are introduced with the promotion of BCC in this region, container shipping company revenues will increase, as will efficiency through the reduction of imbalances. It is well-known that container shipping has increased international trade and played a key role in promoting the second era of globalization (Bernhofen *et al.*, 2016). Thus, increasing container shipping company revenues, reducing repositioning costs, and improving the market environment are all of great importance.

This chapter is organized as follows. In Section 4.2, cluster analysis of factors affecting the progress of containerization is presented. Section 4.3 explains the formulation and analysis using simultaneous equation modeling. Section 4.4 presents the estimation results, and Section 4.5 summarizes and discusses the results found in Sections 4.2 and 4.4.

4.2 Cluster Analysis

4.2.1 Data and Variables

In this section, factors affecting the progress of containerization are examined using cluster analysis. Traded goods are grouped according to characteristics, and the characteristics of the groups are analyzed. Container trade volume (MT basis), bulk trade volume (MT basis), container trade amount (USD basis) and bulk trade amount (USD basis) in the East Asia region are analyzed using IHS Markit's world trade data. Bulk trade volume is calculated as total seaborne trade volume less container trade volume, including cargo carried by general cargo ships in addition to bulk carriers. IHS Markit gathers trade statistics for each country and estimates the amount of transportation and trade value by transportation mode for each item, classifying goods in accordance with ISIC codes. The containerization rate is calculated by dividing the container shipping volume by the total seaborne trade volume. Goods with an average containerization rate from 2000 to 2014 of either more than 99% or less than 1% were judged to have no competition between container shipping and bulk shipping, and were excluded. This left 127 goods for analysis.

The following seven variables were used: [1] change in containerization rate (percentage points) between 2007 and 2000, [2] change in containerization rate (percentage points) between 2014 and 2007, [3] average containerization rate (%) from 2000 to 2014 (4) average unit price (USD/kg) between 2000 and 2014, [5] average seaborne trade volume (MT) between 2000 and 2014, [6] change in container trade volume (MT) between 2000 and 2014, and [7] change in bulk trade volume (MT) between 2000 and 2014.

These variables were used for the following reasons. [1] The changes in the containerization rate up to and after 2007 were calculated because Rodrigue and Notteboom (2015) pointed out that the conversion from general cargo transport to container transport stagnated from around 2007. [2] The average containerization rate was used to determine whether the stagnation in the growth of containerization occurred following the completion of the conversion to containerized shipping. [3] Container trade volume and bulk trade volume were calculated to assess whether the significant reduction in bulk trade volume caused the containerization rate to rise despite the decrease in container trade volume. [4] The average unit price and average seaborne trade volume were adopted because these are crucial factors affecting containerization, and are also useful elements for classifying goods.

Cluster analysis uses the *k*-means method, which is non-hierarchical and divides N observations into *k* clusters. Data are assigned to each cluster in accordance with the evaluation function shown below. The distance between representative point $\boldsymbol{\mu}_i$ of cluster S_i and data $\mathbf{x}$ is expressed by $\left\| \mathbf{x} - \boldsymbol{\mu}_i \right\|$. *k*-means clustering assigns data $\mathbf{x}$ to cluster S_i so that $\boldsymbol{\mu}_i$ is the nearest representative point for all $\mathbf{x} \in S_i$ that satisfies evaluation function (4.1).

$$\min_{\mathbf{x}} \sum_{i=1}^{k} \sum_{\mathbf{x} \in S_i} \left\| \mathbf{x} - \boldsymbol{\mu}_i \right\| \tag{4.1}$$

The *k*-means method requires the number of clusters to be determined *ex ante*. Thus, three standards were applied: (1) whether the containerization rate was high, (2) whether growth in the containerization rate was large, and (3) whether the demand for seaborne trade volume was growing. At least eight clusters are considered necessary to assess these factors, and so ten clusters were used to provide a margin for error.

4.2.2 Results of Cluster Analysis

The results of the cluster analysis are shown in Table 4.1. The values shown in each cell are the average values for goods included in each cluster. The goods in each cluster are shown in Table 4.2[21].

Even though there is a considerable difference between Cluster 1 (14.3%) and Cluster 7 (2.1%), the change in the containerization rate from 2000 to 2007 shows that containerization was progressing across all clusters, confirming that containerization advanced during that period. Conversely, the increase in the containerization rate declined between 2007 and 2014,

[21] Detailed results are shown in Appendix I.

when even Cluster 9, which showed the most growth, only increased by 4.3%, while the changes in the containerization were negative for Clusters 2, 3, 4, and 7. Overall, progress in containerization stalled around 2007.

Table 4.1 Results of the Cluster Analysis

Cluster No.	No. of goods	Change in Containerization Rate from 2000 to 2007	Change in Containerization Rate from 2007 to 2014	Containerization Rate	Unit Price ($/kg)	Seaborne Trade Volume (10,000 tons)	Change in Container Cargo (10,000 tons)	Change in Seaborne Trade (10,000 tons)
1 (Middle)	8	14.3%	2.1%	59.5%	0.65	590	315.0	77.4
2 (Middle)	5	9.5%	–8.0%	61.9%	1.05	1,302	599.5	338.9
3 (High)	44	5.7%	–0.1%	76.2%	10.52	23	7.2	0.5
4 (High)	3	8.2%	–0.4%	93.8%	4.22	136	–30.3	–9.8
5 (High)	20	10.5%	1.6%	79.2%	2.59	231	137.1	1.4
6 (High)	25	7.6%	1.1%	87.1%	7.13	83	48.3	1.2
7 (Low)	10	2.1%	–0.1%	24.7%	1.76	214	42.8	105.6
8 (Low)	5	4.9%	2.3%	20.7%	0.57	2,943	653.4	1,483.7
9 (Middle)	3	9.9%	4.3%	56.2%	0.43	154	–27.4	–75.2
10 (Low)	4	3.0%	0.9%	11.3%	0.56	757	104.1	610.7

Table 4.2 Rough Classification of Goods for Cluster Analysis

Cluster No.	Number of Goods	Goods
1(Middle)	8	Stones and Cements, Fertilizers, Building Materials, Recycling Goods
2(Middle)	5	Chemical Products, Fruits and Vegetables, Woods
3(High)	44	Machinery, Agricultural Products
4(High)	3	Cotton, Synthetic Fibers, Apparel Raw Materials/Products
5(High)	20	Metals, Iron, Chemical Elements, Industrial Machinery, Drinks, Plastic Products
6(High)	25	Fruits, Vegetables, Machines, Foods, Clothing
7(Low)	10	Fertilizers, Feed Materials, Animal and Vegetable Oils, Rice, Wood Chips, Motor Vehicles
8(Low)	5	Steel Products, Organic Compounds, Stones
9(Middle)	3	Fertilizers, Phosphate, Paper, Oilseeds, Fruits for Oil Extraction
10(Low)	4	Petroleum Products, Oils, Cokes, Scrap Metals

Clusters 3, 4, 5, and 6, which have a high average containerization rate, include goods such as fresh food, machinery, and apparel. These clusters tend to contain small goods and high-value goods. Conversion from general cargo transport to container transport has advanced further for these goods than for those in other clusters, with containerization achieving significant progress by around 2007.

Machinery and agricultural products account for the majority of goods in Cluster 3, with the average unit price being the highest among all clusters. However, the average containerization rate is lower for this cluster than it is for Clusters 4, 5, and 6. The growth in the volume of container trade is also moderate compared with that in Clusters 5 and 6, and the growth in the containerization rate since 2007 is slightly negative. However, the growth in bulk trade volume over the same period has been small. It is worth noting that goods in Clusters 3, 4, 5, and 6 also have a low containerization rate. For example, the containerization rate of grapes and plums is about 60%. In addition, there are specific routes where the containerization rate for the cluster as a whole is low, for example, the containerization rates for the Philippines–China route and the Malaysia–Vietnam route are less than 50%. This may be related to the lack of container services on these routes. According to the Alphaliner database, only 38 services are offered on the Philippines–China route including semi-liners and roll-on/roll-off (RO-RO) ship services. This is extremely low comparing with the 135 services offered on the China–Vietnam route and the 155 services offered on the China–Taiwan route. The Malaysia–Vietnam route is also underserviced, with only 45 services on offer.

Cluster 4 includes goods such as apparel-related raw materials and products. Between 2000 and 2014, container trade volumes and bulk trade volumes were decreasing, but the decrease in container trade volumes was more significant than that in bulk trade volumes. Since containerization of goods in this cluster was considerably advanced, the decrease in container trade volumes mainly reflected the decrease in trade volumes[22].

[22] Nippon Kaiji Kentei Kyokai (2015) analyzed trade trends for apparel-related goods in Asia (from Northeast Asia to India) in 2003 and 2013. In terms of synthetic fibers and textiles, procurement by Chinese importers

In Clusters 5 and 6, the container trade volume has increased significantly even though the bulk trade volume has hardly increased at all. Thus, the goods in these clusters are those for which container transportation has remained fixed to some extent. Cluster 5 contains goods such as aluminum, concrete products, and steel materials. These goods are larger in volume than those in Cluster 6, which includes goods such as machines, food, and clothing. Cluster 5 contains goods with low unit prices.

Clusters 1, 2, and 9, which have medium average containerization rates, include goods such as building materials and chemical products. The unit price of goods in these clusters is around 1 USD/kg or less, which is considerably lower than that of goods in the Clusters 3, 4, 5 and 6. Containerization of goods in these clusters advanced significantly up to around 2007, but the situation varies from 2007 onwards.

Cluster 1 contains goods such as building materials and recycling materials. The container trade volume and bulk trade volume were both increasing, and increases in the container trade volumes were larger than those in bulk trade volumes before 2007. Even after 2007, changes in container trade volumes are higher for more than half of the goods in this cluster. Therefore, since 2007, the growth in the average containerization rate for this cluster has been small but positive.

The goods in Cluster 2 include chemical products, wood, and fruits. The containerization rate in this cluster has declined since 2007 because of the significant increase in bulk trade volumes in the latter half of the 2000s. For example, exports of processed fruit goods from Thailand to China have increased significantly since the latter half of the 2000s, but the containerization rate fell sharply because bulk transport was mainly used.

Cluster 9 contains goods such as fertilizers and raw materials such as phosphate, newspaper and uncoated paper, oilseeds, and fruits for oil extraction. As the procurement of these goods

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increased as a result of economic development. This caused a reduction in the trade volumes of goods in Cluster 4.

has switched from domestic sources to suppliers outside East Asia, the seaborne trade volume in East Asia has been on a downward trend. Moreover, the containerization rate rose because the bulk trade volume decreased more than the container trade volume. This is a case where container transportation remained steady despite trade shrinkage.

Clusters 7, 8, and 10, which have low average containerization rates, include goods such as metals, stones, and cooking oil. The unit prices of goods in these clusters are 1 USD/kg or less, which is about the same as that of goods in clusters with medium average containerization rates. In addition, the average seaborne trade volumes are the largest in these clusters because goods in these clusters tend to be heavy. Containerization of these goods did not progress significantly until around 2007, and so the bulk trade volume increased more than the container cargo volume from 2000 to 2014.

Goods in Cluster 7 include fertilizer, feed materials such as hay, animal and vegetable oils, rice, and wood chips. Unit costs and average seaborne trade volumes are similar to those of Cluster 5, but there is a big difference in the average containerization rate. Containerization rates for around half of the goods in Cluster 7 declined from 2007. Conversely, the containerization rates did not decrease for the rest of the goods in the cluster, while they rose slightly for fertilizer raw materials, foods such as meat and fish, and hay.

Cluster 8 includes goods such as steel products, organic compounds, and stones. Overall, although the containerization rates for these goods are low in East Asia, some goods such as stones, which are in high demand for tombstones, account for the highest trade volumes, with significant volumes of container trade between Japan and China and between Japan and Korea (Matsuda, 2014; Matsuda, 2016).

Goods in Cluster 10 include petroleum products, oils, cokes, and scrap metals. The unit prices of these goods are the second lowest, and average containerization rates are the lowest of any cluster. Some practitioners believe that transportation in dedicated containers looks promising for goods in this cluster. In addition, container transportation of scrap metal still accounts for a significant share of exports from the US to countries such as Taiwan and Turkey.

Finally, it is worth discussing seasonal fluctuations in demand for goods. As can be seen from Table 4.2, goods such as food crops and raw materials, which experience seasonal fluctuations in demand, are contained in clusters that have both high and low average containerization rates. However, also can be seen from Table 4.2, it seems to be apparent that containerization rates tend to be relatively higher in relation to goods for which seasonal fluctuations in demand are less significant. Therefore, the existence of seasonal fluctuations in demand may not have a significant influence on the choice of transport mode. That is, except for sharp fluctuations in demand, there is not much hedging of risk through the choice of transport mode. However, there is a possibility that hedging of risk is occurring on various individual routes because the cluster analysis conducted in this chapter combined the route information.

4.3 Outline of Simultaneous Equations Model

4.3.1 Model Formulation

In the simultaneous equations model, containerization rates in relation to imports and exports between exporting and importing countries are regarded as the final dependent variable. In addition, the extent of the influence of trade characteristics such as seaborne trade volume and import and export costs on both the exporting country and the importing country is identified. That is, the containerization rate Y_{it} in year t of bilateral trade i is estimated using equations (4.2) – (4.4).

$$\begin{cases} Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_{it} + \boldsymbol{\beta}_3 \mathbf{L}_{it}^1 + \varepsilon_{it} & (4.2) \\ X_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 Z_{it} + \boldsymbol{\alpha}_3 \mathbf{L}_{it}^2 + \eta_{it} & (4.3) \\ Z_{it} = \gamma_0 + \gamma_1 X_{it} + \gamma_2 Y_{it} + \boldsymbol{\gamma}_3 \mathbf{L}_{it}^3 + \mu_{it} & (4.4) \end{cases}$$

The seaborne trade volume in year t of bilateral trade i is indicated by X_{it}. The ratio of the container freight rate to the bulk freight rate is indicated by Z_{it}. $\mathbf{L}_{it}^{1}$, $\mathbf{L}_{it}^{2}$, and $\mathbf{L}_{it}^{3}$ are vectors of exogenous variables used in equations (4.2), (4.3), and (4.4), respectively. ε_{it}, η_{it}, and μ_{it} are error terms used in each equation.

Equation (4.2) provides a formula for calculating containerization rates, which is the ultimate objective of the analysis. It aggregates individual transportation mode decision-making, which determines the containerization rate based on the seaborne trade volume and the freight rates for container shipping and bulk shipping and other factors.

Equation (4.3) is used to estimate the seaborne trade volume in bilateral trade. It aggregates individual decision-making regarding the seaborne trade quantity (i.e., the lot) based on the containerization rate, the freight rates and the sizes of the economies of the exporting country and the importing country. In estimating this formula, bilateral maritime distance was adopted as an explanatory variable in relation to the transportation cost. Real GDP is used to measure the size of a country's economy. Equations (4.2) and (4.3) are both demand functions that determine the demand for seaborne trade volume and container trade volume, respectively.

Equation (4.4) is used to estimate the relative freight rate of container shipping and bulk shipping based on the seaborne trade volume, containerization rate, and other factors. Equation (4.4) is a collection of supply functions in relation to container shipping and bulk shipping. It should be noted that not only the relative levels of container freight and bulk freight but also the overall freight level influence decision-making. Thus, it is preferable to build a model based on absolute values. However, because it is difficult to collect bulk freight data on an origin and destination (OD) basis, estimations are made using a model that determines the relative freight rate of container shipping and bulk shipping.

4.3.2 Notes on the Analysis

First, it is worth noting again the period over which goods shipped by either bulk transport or container transport are consumed. As stated in Section 2.8, once a transport mode is selected, a specified period of time must elapse until the next selection can be made.

In an interview, a consignee confirmed the above statement and mentioned that the ratio of bulk shipping to container shipping is initially determined for each route in accordance with the management plan drawn up at the beginning of the fiscal year. However, even if the consignee wishes to use bulk shipping, container shipping might be used temporarily when the consignee wants to import cargo quickly and is not prepared to wait until sufficient cargo is accumulated for a bulk shipment. Many companies formulate management plans for periods of three months, six months, and one year, and review their long-term management plans annually. Although there are differences in accounting systems and practices among countries and companies, shippers/consignees usually make decisions once or several times per year. The formulation of the model presented here, in which a decision is made once a year, makes it possible to examine trends in the selection of the transport mode in aggregated form.

The formulation of the simultaneous equations model reflects the fact that seaborne trade volumes, containerization rates, and freight rates are determined at the same time. When a person exports or imports a specific good via a specific route, he/she usually decides on the transport mode and the shipping volume at the same time. Due to negotiations between shipping companies and their customers, not only the freight rates but also the cargo quantity and the share of various transport modes will fluctuate. Thus, the cargo quantity and transportation mode share is determined at the same as the freight rates. Even shippers/consignees who use bulk shipping and container shipping at the same time or who contract with multiple shipping companies and forwarders may experience some timing variations. However, there is no problem if seaborne trade volumes, container freight volumes (containerization rates), bulk freight rates, and container freight rates are determined almost simultaneously[23].

When estimating the simultaneous equations model, the endogeneity problem occurs where the endogenous variable and the error term are correlated[24]. To deal with this, the three-stage least squares method (3SLS) is used. First, each endogenous variable is regressed on all exogenous variables. Second, using the previous regression-estimated values as instruments, all equations are estimated using the ordinary least squares (OLS) method to compute residuals and determine cross-equation correlations. Third, the generalized least squares (GLS) method is used to estimate model parameters.

In estimating equation (4.2), the range of the dependent variable Y_{it} is limited to [0,1]. However, OLS and GLS do not restrict the range, and thus might be inappropriate for this analysis. Therefore, the natural logarithm of the odds ratio is used, which is defined as $\ln\left(Y_{it}/1-Y_{it}\right)$[25]. However, because $\lim_{Y_t \to 1} \ln\left(Y_{it}/1-Y_{it}\right) = \infty$, data are excluded from the estimation when $Y_{it} = 1$[26].

Trade between neighboring countries with land borders is also considered. In this chapter, 11 East Asian countries (Japan, South Korea, China, Hong Kong, Taiwan, Vietnam, the Philippines, Indonesia, Thailand, Malaysia, and Singapore) comprise the sample. However, in cases where countries share a land border, transportation by a land-based service becomes an option in addition to container shipping and bulk shipping, which affects both the transport mode decision and containerization rates. Therefore, the following country combinations

[23] Murakami and Matsuse (2014) applied almost the same methodology as that used in the econometric model used in this chapter to estimate the choice between container shipping and air transport.

[24] If there is endogeneity, a correlation between the explanatory variables and the error term is present, and the estimated coefficients lose their consistency. Thus, OLS is not an appropriate estimation method.

[25] This is the logit conversion, thus this estimation can be regarded as a logit model using aggregated data.

[26] Some observations in Cluster 4 were excluded.

were excluded from the analysis: China–Vietnam, China–Hong Kong, Malaysia–Singapore, Malaysia–Thailand, and Malaysia–Indonesia.

Finally, there is a limitation to the analysis conducted in this chapter. Here, regression analyses are performed for each cluster. However, cluster analysis is conducted for container transportation throughout East Asia, and thus information on the degree of containerization applicable to each route is abstracted. Average containerization rates by OD and cluster are shown in the tables in Appendix II. It is worth noting that the result of the regression analysis is based on the clusters into which the containerization on each route is grouped. Table 4.3 indicates differences in containerization rates between the results of the cluster analysis and the average for each route. In fact, the difference between the containerization rates for each cluster shown in Table 4.1 and the average containerization rates for each cluster shown in Appendix II does not exceed 10% except for Clusters 7 and 9. However, there is a possibility that the results of the regression analysis deviate from the actual degrees of containerization as a result of the method of analysis, especially in relation to Clusters 7 and 9.

Table 4.3 Differences in Containerization Rates between the Results of Cluster Analysis and the Average for Each Route

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
Cluster Analysis	59.5%	61.9%	76.2%	93.8%	79.2%	87.1%	24.7%	20.7%	56.2%	11.3%
Appendix	52.4%	64.7%	75.7%	90.2%	80.8%	90.4%	37.3%	21.9%	85.2%	11.2%
Difference	7.1%	–2.8%	0.5%	3.6%	–1.6%	–3.3%	–12.6%	–1.2%	–29.0%	0.1%

4.3.3 Explanatory Variables, Dependent Variables, and Data

Table 4.4 shows the explanatory variables, dependent variables, and data used in the analysis. At the time of estimation, natural logarithms are taken for all variables excluding containerization rates and the relative volumes of container shipping and bulk shipping. This enables the coefficients to be compared in percentage terms, making the results easier to interpret (Stock and Watson, 2007).

Table 4.4 Data Outline and Summary Statistics

Variable	**Unit**	**Data Source**	**Average**	**Standard**	**Observations**
Exogenous Variables Used for Estimating the Containerization Rate (Y_{it})					
Container Handling in Exp. Country	TEU	UNCTAD, MLIT	25,780,806	36,404,639	54
Container Handling in Imp. Country	TEU	UNCTAD, MLIT	25,780,806	36,404,639	54
Cost of Export in Exp. Country	USD/Container (PPP)	WB "Doing Business"	710	200	99
Cost of Import in Imp. Country	USD/Container (PPP)	WB "Doing Business"	785	283	99
Container Trade Imbalance	TEU	IHS Markit	32	195,298	1,487
Exogenous Variables Used for Estimating the Seaborne Trade Volume (X_{it})					
Real GDP of Exp. Country	Mil. USD (2005)	World Bank	1,041,226	1,587,146	99
Real GDP of Imp. Country	Mil. USD (2005)	World Bank	1,041,226	1,587,146	99
Distance	Nautical Miles	AXS Alphaliner	1,503	788	110
Exogenous Variables Used for Estimating the Relative Freight Rate (Z_{it})					
Bulk Carrier Capacity for the Previous Year	Mil. DWT	Clarksons Research	577	123	5
Container Ship Capacity for the Previous Year	1,000 TEUs	Clarksons Research	14,702	1,895	5
Bunker Oil Price for the Previous Year (380 CST, Singapore)	USD/MT	Clarksons Research	554	115	5
Exogenous Variables Used for Estimating Various Endogenous Variables					
Unit Price	USD/kg	IHS Markit	6	21.98	13,545
Dummy for each year	-	-	-	-	-
Endogenous Variables					
Containerization Rate (Y_{it})	%	IHS Markit	0.59	0.31	12,711
Seaborne Trade Volume (X_{it})	MT	IHS Markit	547,807	1,633,330	13,545
Container Freight Rate (Z_{it})	USD/FEU	Drewry Shipping Consultants	949	248	494
BDI (Z_{it})	Index	Baltic Exchange	2,977	2,279	9

Containerization rates and relative freight volumes are ratios, and thus do not take natural logarithms. Because the acquisition of freight rate data between ports was restricted, the analysis period was set from 2010 to 2014. Based on the results of the cluster analysis, 127 goods were aggregated into 10 clusters. In addition, the value of each variable such as seaborne trade volume and container trade volume was aggregated by cluster.

a) Exogenous Variables Used for Estimating the Containerization Rate (Y_{it})

The exogenous variables used in equation (4.2) to estimate containerization rates are the container handling volume of importing and exporting countries, import and export costs of importing and exporting countries, and imbalance in container trade volumes.

The container handling volume of the exporting and importing countries shows the number of containers handled (throughput) in the form of export, import, transshipment, and empty container transportation at the port of each country during the year in question. For countries other than Japan, the annual figures published by UNCTAD are used, while figures published by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) are used for Japan. In this chapter, the container handling volume is used as a proxy for the processing capacity of the country’s port infrastructure. Container shipping seems to be utilized more at ports with high throughput because containers are handled more efficiently at these ports, and numerous container vessels visit these ports, thus empty containers are more readily available for use. Therefore, containerization rates should be higher in countries with more active ports.

The export costs for the exporting countries and the import costs for the importing countries were obtained from the “Doing Business” database published by the WB. These data are based on information provided by private-sector experts in international logistics. The cost of exporting and importing one container of cargo is converted into dollars, and price fluctuations are taken into account. This cost is a proxy not only for land transportation in the country but also for institutional or soft infrastructure because when the country’s legal system does not impede transportation, the procedural costs, which reflect the country’s level of soft infrastructure, will be low. A rise in these costs is likely to lower the containerization rate because they inhibit the use of container transportation.

The imbalance in container trade volume between countries is the difference between the export volume and the import volume of container cargo for all goods. For the purposes of this chapter, the imbalance is defined as “the container trade volume imported by the importing country from the exporting country” less “the container trade volume exported by the importing country to the exporting country” and is calculated using IHS Markit data. For example, the imbalance when Japan is the exporting country and China is the importing country is the container trade volume imported by China from Japan less the container trade volume exported from China to Japan. A rise in the imbalance means that the import volume has become relatively larger in relation to the export volume. This places downward pressure on the container freight rate for exports, and thus should increase the volume of containerized exports.

b) Exogenous Variables Used for Estimating the Seaborne Trade Volume (X_{it})

The exogenous variables used in equation (4.3) to estimate the seaborne trade volume are the real GDP of the exporting and importing countries and the ocean distance between them.

Real GDPs (base year 2005) were obtained from the WB database, while ocean distances were obtained from the AXS Alphaliner database. The distance between the exporting country and importing country is defined as the distance between the largest container port in each country. The largest container ports in each country are Tokyo (Japan), Busan (Korea), Shanghai (China), Kaohsiung (Taiwan), Hong Kong (Hong Kong), Port Kelan (Malaysia), Singapore (Singapore), Laem Chabang (Thailand), Cai Mep (Vietnam), Tanjung Priok (Indonesia), and Manila (the Philippines).

c) Exogenous Variables Used for Estimating the Relative Freight Rate (Z_{it})

The exogenous variables used in equation (4.4) to estimate the relative freight rate are the bulk carrier volume for the previous year, the container ship volume for the previous year, and the average bunker price for the previous year[27]. The overall capacity of ships indicates

[27] Using the previous year’s data avoids the simultaneity problem concerning the determination of the capacity of the vessels.

the potential supply level. Decisions regarding shipping services in the current period are based on capacity in the previous period because shipping companies have to decide on shipping capacity in advance. An increase in bulk carrier capacity shifts the bulk trade supply curve to the right, leading to a fall in bulk freight rates. Meanwhile, an increase in container shipping capacity shifts the supply curve for container trade to the right and leads to a fall in container freight rates. However, it is not clear in advance how these effects will affect the relative freight rates[28].

In addition, the bunker cost accounts for a large percentage of the operating expenses. For example, for the three Japanese shipping companies Nippon Yusen Kaisha, Mitsui O.S.K. Lines, and Kawasaki Kisen Kaisha, fuel costs accounted for 31.2% of their operating expenses for FY 2015[29]. Therefore, bunker price fluctuations affect market conditions through changes in operating costs. In some cases, a bunker adjustment factor is applied to raise or lower freight rates according to past fuel prices. In general, container ships are faster and consume more fuel (International Maritime Organization, 2009). Therefore, an increase in the fuel price places upward pressure on container freight rates.

d) **Exogenous Variables Used for Estimating Equations (4.2), (4.3), and (4.4)**

Of the explanatory variables, the unit price and year dummies are used in plural equations. The unit price is the average unit price for each cluster in bilateral trade, and is calculated by dividing the seaborne trade value by the seaborne trade volume. In the cluster analysis, the average containerization rate tended to increase for goods with higher unit prices. There is an incentive for each shipper/consignee to reduce inventory costs by decreasing the volume per shipment because inventory costs tend to be higher for goods with higher unit prices.

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[28] For example, assuming that the supply functions for bulk trade and container trade are linear, the relative freight rate is calculated using the first approximation method. Then, the signs of the coefficients of the shipping capacities are affected by the constant term signs of the original supply functions. Therefore, it is not possible to specify beforehand whether the sign of the ship's capacity is positive or negative in the estimation formula.

[29] Weighted average value of bunker costs as a share of operating expenses in the non-consolidated income of Nippon Yusen Kaisha, Mitsui O.S.K. Lines, and Kawasaki Kisen for the 2015 fiscal year.

Because container transportation is appropriate for small-lot transport, it is likely that the containerization rate will rise as the unit price increases.

Dummies are used for trade in years other than 2010 to indicate that the trade was conducted during that year. The reason for using a year dummy is to enable more accurate estimation by controlling for each year's unique effects that are unable to be represented by variables in the model. Since the importance of controlling the effects unique to each year does not change even if the goods change, year dummies were not excluded *a priori* when analyzing specific clusters[30].

e) Endogenous Variables

The relative freight rate is used as an endogenous variable in addition to the containerization rate and the seaborne trade volume. This is obtained by dividing the container freight rate by the bulk freight rate. Monthly container freight rates between various ports are published by Drewry Shipping Consultants, and are based on the average of spot freight rates collected from forwarders at each port. The annual average is used in this chapter. In cases where no data are available the freight rates from/to the nearest port are used.

The bulk freight rate is based on the BDI, which is the daily index of bulk carrier charter fees published by the Baltic Exchange. This calculates the weighted averages of ship sizes and freight rates that are reported by shipbrokers called panelists in relation to all shipping routes. The average annual BDI figures are used in this chapter.

[30] Some dummies are excluded for some years in Table 4.6. This was done by the software package R at the time of estimation to avoid perfect multicollinearity where regression coefficients cannot be determined.

4.4 Results of Simultaneous Equation Modeling

The results of the simultaneous equation modeling are shown in Tables 4.4 to 4.6. The overall system coefficient of determination is shown in the lower part of Table 4.6[31], and varies from 0.60 to 0.97. Thus the estimation results maintain explanatory power.

4.4.1 Results for Seaborne Trade

a) Coefficients of Real GDP and Distance

The estimation results for seaborne trade volume are shown in Table 4.5. The sign of the coefficient of real GDP of the exporting country is significantly positive for each cluster. This indicates that economic development in exporting countries has led to an increase in seaborne trade volume.

The coefficients of real GDP in importing countries are significantly positive in all clusters except for Cluster 4. Economic development and rising demand in importing countries have led to an increase in marine transportation volumes for most goods. Cluster 4 had negative coefficients, but they were not significant. This cluster is made up of raw materials used in light manufacturing industries, and thus it can be inferred that this result was because industrialization in importing countries had advanced with economic development, and thus manufacturers had transferred their bases overseas.

The coefficients of distances between exporting countries and importing countries were positive for all clusters except Cluster 9 and significant for Clusters 2, 7, 8, and 10. This suggests that bulk shipping, which can carry large quantities of cargo at once, is extremely

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[31] The coefficient of determination (adjusted R^2) may take a negative value in the estimation model used in this chapter. In the simultaneous equation model using 3SLS, it is known that the determination coefficients of each equation take a negative value, or more than unity. There are some indications that the coefficient of determination lacks adequacy as an index of explanatory power in simultaneous equation modeling (e.g., Matsuura and McKenzie, 2012). However, to show the explanatory power of the estimation results, the coefficients of determination of the simultaneous equation system (system R^2) are calculated and shown in the lower part of Table 6.

cost competitive for long-distance trade. In addition, goods in Clusters 7, 8 and 10 originally had a low containerization rate, as shown in Table 4.1. Therefore, it is likely that bulk shipping would be used for long-distance trade of goods in these clusters as demand increases. However, in relation to the goods in Cluster 2, which have relatively high unit prices and containerization rates, not only bulk transport but also container transport may be selected, even for long-distance trade.

Table 4.5 Estimation Results for Seaborne Trade

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
GDP of Exporting Country (ln)	0.593***	0.839***	0.992***	0.909***	0.875***	0.841***	0.669***	0.760**	0.597***	0.276***
	(0.060)	(0.057)	(0.064)	(0.101)	(0.044)	(0.056)	(0.073)	(0.255)	(0.083)	(0.101)
GDP of Importing Country (ln)	0.343***	0.642***	0.539***	–0.070	0.434***	0.535***	0.294***	0.458***	0.189**	0.818***
	(0.066)	(0.047)	(0.054)	(0.109)	(0.036)	(0.070)	(0.058)	(0.057)	(0.092)	(0.065)
Distance (ln)	0.125	0.479***	0.118	0.0003	0.079	0.031	0.665***	0.446***	–0.007	0.397**
	(0.125)	(0.104)	(0.118)	(0.140)	(0.079)	(0.119)	(0.152)	(0.103)	(0.129)	(0.160)
Containerization Rate (ln)	0.745*	1.804***	0.945***	–0.674**	–0.135	2.707***	–0.013	2.709**	1.257***	–1.091***
	(0.404)	(0.184)	(0.213)	(0.294)	(0.147)	(0.485)	(0.393)	(1.098)	(0.211)	(0.360)
Container Freight Rate/BDI	2.694***	0.607	–6.157***	1.222	–1.878***	0.463	0.954	–0.871	7.361***	0.667
	(0.823)	(0.775)	(0.708)	(1.067)	(0.558)	(0.751)	(0.962)	(1.257)	(1.075)	(1.090)
Unit Price (ln)	–0.445***	–0.618***	0.213**	–0.179	0.176	0.531***	0.451***	–1.819***	–0.911***	–0.099
	(0.126)	(0.104)	(0.104)	(0.228)	(0.150)	(0.080)	(0.111)	(0.679)	(0.124)	(0.106)
Dummy for 2011	–0.628**	0.014	2.006***	–0.212	0.656***	–0.132	–0.214	0.794**	–1.662***	0.023
	(0.307)	(0.296)	(0.285)	(0.427)	(0.194)	(0.293)	(0.366)	(0.378)	(0.426)	(0.415)
Dummy for 2012	–1.588***	–0.292	4.229***	–1.003	1.356***	–0.267	–0.587	0.916	–4.472***	–0.184
	(0.566)	(0.547)	(0.510)	(0.751)	(0.384)	(0.532)	(0.670)	(0.775)	(0.745)	(0.762)
Dummy for 2013	–0.902**	–0.096	2.512***	–0.555	0.84***	–0.155	–0.384	0.543	–2.814***	–0.045
	(0.369)	(0.357)	(0.336)	(0.523)	(0.250)	(0.350)	(0.437)	(0.482)	(0.501)	(0.497)
Dummy for 2014	–1.253***	–0.223	2.936***	–0.655	0.975***	–0.348	–0.490	0.448	–3.560***	0.096
	(0.440)	(0.419)	(0.386)	(0.600)	(0.300)	(0.419)	(0.515)	(0.608)	(0.593)	(0.576)
Constant	–3.101**	–11.26***	–7.349***	1.146	–3.995***	–12.45***	–6.772***	–3.018	–7.553***	–9.306***
	(1.403)	(1.347)	(1.739)	(2.871)	(1.197)	(1.940)	(1.878)	(4.775)	(1.896)	(1.867)
Observations	472	472	472	367	472	472	472	472	465	470
Adjusted R^2	0.2613	0.2854	–0.3804	0.2958	0.6568	–0.5778	0.3831	0.5637	–0.3390	0.2230

Note 1: Standard errors in parentheses.
Note 2: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

b) Coefficients of Containerization Rates

The coefficients of containerization rates are significantly positive in six clusters (Clusters 1, 2, 3, 6, 8, and 9). In these clusters, seaborne trade volumes are increasing along with containerization rates, and the increase in container shipping contributes to the increase in seaborne trade volumes.

Conversely, when the coefficients of containerization rates are significantly negative, as is the case in Clusters 4 and 10, it is likely that the use of containers reduces the transport volume. Even cargo that previously used bulk shipping will no longer be able to be carried by bulk carriers if demand falls from previous levels. Thus, the transport mode has to be changed. This suggests the possibility of switching to container transport in response to reduced demand.

c) Coefficients of Relative Freight Rates

The trends in the coefficients of relative freight rates differed among clusters. The coefficients for Clusters 3 and 5, which have relatively high containerization rates, are significantly negative. Demands for the goods in these clusters relatively sensitive in relation to container freight rates. If the container freight rate rises, transportation costs will also rise, reducing demand for imports. Meanwhile, Clusters 1, 6 and 9 have significantly positive coefficients. Demands for the goods in these clusters are relatively insensitive in relation to container freight rates. Container transportation is not likely to decrease as much in response to increasing container freight rates. The coefficients of the clusters other than those mentioned above were not significantly different from zero, and thus freight rates did not have a significant influence on seaborne trade volumes. For goods in these clusters, demands are relatively insensitive in relation to freight rates.

4.4.2 Results for Relative Freight Rates

Table 4.6 shows the estimation results for relative freight rates, which represent the ratio of container freight rates to bulk freight rates.

The coefficients of the capacity of bulk carriers in the previous year are significantly negative for all clusters. Thus, the relative freight rate decreases as the bulk carrier capacity increases. The coefficients of the capacity of container ships in the previous year are significantly positive in all clusters. Therefore, the relative freight rate increases as the container ship capacity increases.

Table 4.6 Estimation Results for Relative Freight Rates

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
Capacity of bulk carriers for the previous year (ln)	–60.55***	–60.25***	–60.35***	–58.08***	–59.96***	–61.11***	–59.81***	–59.72***	–58.46***	–58.70***
	(6.605)	(6.958)	(6.645)	(7.860)	(6.641)	(6.813)	(7.458)	(6.633)	(6.853)	(6.953)
Capacity of container vessels for the previous year (ln)	107.4***	106.8***	107.1***	103.0***	106.3***	108.4***	106.1***	105.9***	103.8***	104.0***
	(11.79)	(12.42)	(11.86)	(14.04)	(11.86)	(12.16)	(13.31)	(11.84)	(12.23)	(12.41)
Average Bunker Price for the previous year (ln)	0.111	0.140	0.117	0.145	0.128	0.089	0.103	0.141	0.108	0.169
	(0.145)	(0.153)	(0.146)	(0.174)	(0.146)	(0.150)	(0.164)	(0.146)	(0.151)	(0.153)
Seaborne Trade Volume (ln)	0.066***	0.045***	0.038***	0.027***	0.048***	0.039***	0.07***	0.044***	0.046***	0.036***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.006)	(0.006)	(0.007)
Containerization Rate	–0.026	–0.112***	–0.033*	–0.036*	–0.022	–0.233***	–0.154***	–0.035**	–0.075***	0.043
	(0.026)	(0.019)	(0.019)	(0.022)	(0.015)	(0.049)	(0.050)	(0.015)	(0.012)	(0.037)
Dummy for 2011	–0.007	–0.004	–0.004	0.002	–0.009	–0.002	–0.009	–0.007	–0.016	–0.004
	(0.027)	(0.029)	(0.027)	(0.031)	(0.027)	(0.028)	(0.031)	(0.027)	(0.028)	(0.028)
Constant	–646.8***	–643.0***	–644.7***	–619.9***	–640.4***	–652.3***	–639.1***	–637.9***	–624.7***	–626.1***
	(70.46)	(74.22)	(70.88)	(83.87)	(70.84)	(72.67)	(79.55)	(70.75)	(73.10)	(74.18)
Observations	472	472	472	367	472	472	472	472	465	470
Adjusted R^2	0.5410	0.4802	0.5437	0.5019	0.5432	0.4180	0.4061	0.5637	0.4826	0.4704

Note 1: Standard errors in parentheses.
Note 2: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

The coefficients of seaborne trade volume are significantly positive for all clusters. Thus, the container freight rate increases as the maritime trade volume increases. This is because relatively long contracts ranging from one year to several years are common for bulk shipping. Moreover, the amount carried in one shipment is large, and thus the frequency of bulk shipping is relatively low. Hence, bulk shipping is relatively insensitive to market trends in seaborne trade. In the case of container trade, transportation contracts are generally concluded within one year, and the frequency of container shipping is relatively high. In addition, the proportion of spot cargoes is significant. Therefore, the freight rate incorporates changing market conditions relatively quickly. Indeed, container shipping is considered to have emerged as a result of rapid changes in freight rates in response to changing market trends.

4.4.3 Results for Containerization Rates

a) Coefficients of Container Handling in the Exporting Country

Estimation results for containerization rates are shown in Table 4.7. The coefficients of container handling volumes in exporting countries were not significantly different from zero for Clusters 3 and 6, while they were significantly positive for Clusters 4 and 5. This suggests that products with a high containerization rate might have an insignificant impact on port infrastructure development in exporting countries.

In Clusters 1, 2, and 9, which have medium average containerization rates, the signs differ, although they are all significant. The signs for Clusters 2 and 9 are significantly negative, suggesting that the containerization rate decreases as container port infrastructure development progresses. When infrastructure development is progressing, not only container terminals but also bulk cargo berths are often improved[32]. Thus, in relation to the goods in these clusters, there is a possibility of using dedicated bulk berths to pursue economies of scale following port infrastructure development. The sign of the coefficient for Cluster 1 is significantly positive, suggesting that container shipping has progressed in line with the development of ports.

The results also differ among Clusters 7, 8, and 10, which have low average containerization rates. The coefficients for Clusters 8 and 10, which include numerous types of bulk cargo, are significantly negative. For the goods in these clusters, it is considered that economies of scale will be pursued in line with the development of port infrastructure. For the goods in

[32] The correlation coefficient between global container trade volume (total of export and import volumes) and bulk transportation volume (total of export and import volumes) from 2000 to 2014 was 0.78. This is a strong positive correlation, suggesting that container port development and bulk port development proceed roughly in parallel in a given country.

Cluster 7, which include numerous food products, the coefficient is significantly positive. This suggests that containerization of goods in this cluster will progress in line with port development because containerized shipment of these goods is likely to benefit from improvements in hard infrastructure.

Table 4.7 Estimation Results for Containerization Rates

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
Container Handling in Exp. Country (ln)	0.549***	–0.187***	0.147	0.248*	0.393***	–0.011	0.138***	–0.104***	–0.392***	–0.156***
	(0.159)	(0.057)	(0.147)	(0.142)	(0.132)	(0.049)	(0.049)	(0.026)	(0.080)	(0.041)
Container Handling in Imp. Country (ln)	0.637***	–0.259***	–0.218**	–0.385***	0.129	–0.102**	0.214***	–0.185***	–0.314***	0.480***
	(0.173)	(0.068)	(0.103)	(0.084)	(0.115)	(0.049)	(0.064)	(0.033)	(0.063)	(0.117)
Cost of Export in Exp. Country (ln)	0.600**	–0.382***	–0.134	0.653	0.319	–0.03	0.559***	–0.221*	–0.827**	–0.275
	(0.290)	(0.133)	(0.294)	(0.449)	(0.328)	(0.142)	(0.191)	(0.116)	(0.263)	(0.279)
Cost of Import in Imp. Country (ln)	1.354***	–0.097	0.580**	–1.312***	–0.326	0.056	–0.323**	–0.156***	–0.594***	0.688***
	(0.394)	(0.111)	(0.237)	(0.299)	(0.230)	(0.087)	(0.136)	(0.052)	(0.168)	(0.184)
Container Trade Imbalance (ln)	–0.134**	–0.084**	–0.184***	–0.022	–0.129**	–0.065***	0.001	–0.042***	–0.025	0.136***
	(0.056)	(0.034)	(0.057)	(0.053)	(0.063)	(0.025)	(0.044)	(0.012)	(0.044)	(0.046)
Seaborne Trade Volume (ln)	–0.679***	0.413***	–0.024	–0.246***	–0.411***	0.093*	–0.221***	0.261***	0.543***	–0.407***
	(0.185)	(0.064)	(0.134)	(0.080)	(0.117)	(0.054)	(0.066)	(0.020)	(0.056)	(0.069)
Container Freight Rate/BDI	2.811***	–6.252***	–3.641***	–0.883	–2.801***	–2.304***	1.488**	–1.626***	–6.188***	3.400***
	(0.907)	(0.500)	(0.455)	(0.624)	(0.648)	(0.291)	(0.589)	(0.228)	(0.513)	(0.593)
Unit Price (ln)	0.005	0.224***	0.506***	0.353**	0.750***	–0.012	0.244***	0.626***	0.592***	–0.032
	(0.107)	(0.049)	(0.072)	(0.118)	(0.091)	(0.038)	(0.058)	(0.020)	(0.075)	(0.045)
Dummy for 2011	–0.855***	1.857***	1.048***	0.32	0.633***	0.705***	–0.499**	0.321***	1.485***	–0.953***
	(0.286)	(0.216)	(0.202)	(0.270)	(0.242)	(0.124)	(0.207)	(0.093)	(0.242)	(0.206)
Dummy for 2012	–1.856***	4.125***	2.369***	0.393	1.795***	1.522***	–1.079***	0.946***	3.714***	–2.12***
	(0.588)	(0.371)	(0.347)	(0.459)	(0.448)	(0.211)	(0.408)	(0.167)	(0.393)	(0.414)
Dummy for 2013	–1.045***	2.44***	1.505***	0.097	1.073***	0.919***	–0.696***	0.551***	2.203***	–1.230***
	(0.359)	(0.262)	(0.251)	(0.343)	(0.297)	(0.146)	(0.267)	(0.116)	(0.288)	(0.277)
Dummy for 2014	–1.283***	3.024***	1.961***	0.179	1.349***	1.177***	–0.813**	0.756***	2.85***	–1.419***
	(0.448)	(0.306)	(0.288)	(0.394)	(0.354)	(0.168)	(0.319)	(0.135)	(0.326)	(0.323)
Constant	–23.82***	9.313***	2.443	11.72*	0.524	4.603**	–6.159**	3.982**	21.57***	–9.193***
	(7.473)	(2.400)	(5.226)	(6.360)	(5.658)	(2.193)	(2.681)	(1.625)	(3.790)	(2.367)
Observations	472	472	472	367	472	472	472	472	465	470
Adjusted R^2	–1.231	–2.011	–0.1295	0.1115	0.1152	–0.4119	–0.5661	0.5755	–0.8296	–2.012
System R^2	0.6585	0.9710	0.7266	0.7711	0.7112	0.9210	0.6019	0.9230	0.9478	0.7643

Note 1: Standard errors in parentheses.
Note 2: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

b) Coefficients of Container Handling in Importing Countries

The coefficients for container cargo handling volumes in importing countries are significantly negative for all clusters with high average containerization rates except Cluster 5 and all clusters with medium average containerization rates except Cluster 1. This reflects the fact that bulk shipping increases and containerization rates fall in importing countries with well-established port infrastructure. In Clusters 7 and 10, which have low average containerization rates, the coefficients are significantly positive, suggesting the possibility of increasing the containerization rate if the port infrastructure is improved.

c) Coefficients of Export Costs in Exporting Countries and Import Costs in Importing Countries

The coefficients of export costs in exporting countries are insignificant for Clusters 4, 5, and 6, which have high average containerization rates. The goods in these clusters are relatively expensive, and it seems that even a slight change in export costs will be insufficient to change the transport mode. However, the sign of the coefficient for Cluster 3 is significantly negative, suggesting that an increase in export costs results in a fall in the containerization rate.

For Clusters 1, 2, and 9, which have medium average containerization rates, the coefficients are significantly negative for Clusters 2 and 9, suggesting that an increase in export costs reduces containerization rates. Practitioners have pointed out that customs clearance and procedural burdens in relation to container shipping are greater for container shipping than for bulk shipping. Thus, for goods that do not have a high containerization rate, these burdens may hinder the increase in container transport. The coefficient for Cluster 1 is significantly positive, suggesting that an increase in export costs leads to an increase in containerization rates.

For Clusters 7, 8, and 10, which have low average containerization rates, the results differ among clusters. The signs of the coefficients for Clusters 8 and 10 are negative, while the coefficient for Cluster 7 is significantly positive. The results for Clusters 8 and 10 suggest that increased export costs will reduce containerization rates, while the result for Cluster 7 suggests that they will increase container shipping.

The coefficients of import costs in importing countries are negative in six clusters (Clusters 2, 4, 5, 7, 8, and 9), suggesting that an increase in import costs reduces container shipping of goods in these clusters. However, the coefficients for Clusters 1, 3, and 10 are significantly positive. Although goods in Cluster 3 do not seem to be responsive to increased import costs because of their high unit prices, shippers/consignees of goods in Clusters 1 and 10 do not seem to be concerned about increased import costs despite the low unit price.

d) Coefficients of Unit Prices, Imbalances, Seaborne Trade Volumes, and Relative Freight Rates

The coefficients of unit prices are significantly positive for all clusters except Clusters 1, 6, and 10. This is consistent with the conventional view and the result in Chapter 2 that container shipping is chosen for goods of high value. Clusters 6 and 10 have negative coefficients.

The coefficients of imbalance are significantly negative for Clusters 1, 2, 3, 5, 6, and 8, while they are insignificantly negative for Clusters 4 and 9. These results suggest a tendency for the containerization rate not to become too high on routes where there is a significant imbalance, that is, routes where imports are greatly exceeded by exports. The coefficients were insignificantly positive for Cluster 7, and significantly positive for Cluster 10. This implies that the containerization rates for goods in these clusters may increase as the imbalance increases. As shown in Table 4.1, goods in Clusters 7 and 10 include many types of bulk cargo with low containerization rates and low unit prices. Therefore, shipments of these goods in containers may be a useful tool for addressing imbalances. Conversely, the coefficients for Clusters 1 and 8, which also include bulk cargo, are negative, and thus container shipping is not progressing in relation to these clusters, even on routes with large imbalances. In promoting BCC as a means of alleviating imbalances, it will be necessary to consider how to promote containerization of these kinds of goods.

The coefficients of seaborne trade volume were negative for all clusters with a high average containerization rate (Clusters 3, 4, 5, and 6) except for Cluster 6. This suggests that an increase in the seaborne trade volume does not lead to an increase in the containerization rate for goods that already have a high containerization rate. Moreover, this is consistent with the recent stagnation in the progress of containerization in relation to highly containerized goods. The coefficients of seaborne trade volume were significantly positive for all clusters with a moderate average containerization rate (Clusters 1, 2, and 9) except for Cluster 1. This suggests that there is a high possibility that new cargo in these clusters is being carried in containers. For Cluster 2, although the bulk trade volume increased in the latter half of the 2000s, the overall containerization rate has been declining, suggesting that the containerization rate may be higher for routes with greater seaborne trade volume. In addition, because the trade volumes of goods in Cluster 9 are decreasing overall, seaborne cargo tends to be transported by containers where bilateral trade survives. The coefficients of seaborne trade volume for clusters with a low average containerization rate (Clusters 7, 8, and 10) are significantly negative except for Cluster 8. Again, this suggests that there is a tendency to choose bulk transportation in pursuit of economies of scale on routes with a significant amount of seaborne trade. Conversely, the coefficient for Cluster 8 is significantly positive, suggesting that container shipping is frequently used on routes with a significant volume of seaborne trade.

The coefficients for relative freight rates in clusters with high average containerization rates (Clusters 3, 4, 5, and 6) and those with medium average containerization rates (Clusters 1, 2, and 9) suggest that the rise in container freight rates has reduced the containerization rate. However, the results for clusters with low average containerization rates (Clusters 7, 8, and 10) are somewhat different, suggesting that the rise in container freight rates should not be taken into account.

4.5 Chapter Conclusion

This chapter analyzed the factors relating to BCC in maritime trade in East Asia. First, cluster analysis was undertaken using data on seaborne trade volumes from 2000 to 2014 and trends in the progress of containerization by goods were identified. Goods that were not transported at all or goods that were almost exclusively transported by container were excluded. The 127 goods that remained in the sample were divided into 10 clusters based on seven criteria including trends in the containerization rate and unit prices.

The results of the cluster analysis presented in Section 4.2 revealed the following findings. [1] Regardless of the cluster, as Rodrigue and Notteboom (2015) pointed out, the progress of containerization stagnated around 2007. [2] Clusters with high average containerization rates have low average transport volumes and unit prices. [3] Clusters with low average containerization rates did not experience much progress in containerization even before 2007. [4] Containerization rates may be relatively high even for goods belonging to clusters with low average containerization rates on some trade routes. [5] There is room for further progress in containerization of some goods on specific routes, even goods in clusters that already have high average containerization rates.

Next, the factors influencing the containerization rates for each cluster were analyzed using simultaneous equation modeling. Explanatory variables included imbalances, container trade volumes, seaborne trade volumes, container handling volumes of exporting countries and importing countries, and unit prices of goods.

The results of the analysis presented in Section 4.4 revealed the following findings. [1] The impact of seaborne trade volumes on containerization rates is positive for goods with a medium average containerization rate and negative for goods with a low average containerization rate. Significantly positive correlations between seaborne trade volumes and containerization rates were not evident for goods with a high average containerization rate. [2] The impact of relative freight rates on containerization rates is negative except for goods with a low average containerization rate. [3] Container port development in importing countries may raise containerization rates for goods with a low average containerization rate, but bulk transportation facilities are generally developed at the same time. [4] Reducing the export costs of exporting countries, mainly in relation to goods with a low average containerization rate, may encourage increased container transportation. [5] Reductions in import costs of importing countries also encourage increased container transportation. [6] There is a tendency for goods of high value to be transported by container. [7] For some goods, BCC can be a useful tool for reducing imbalances. [8] For some bulk cargoes, even though containerization has not been used thus far to resolve imbalances, BCC should be considered in relation to the transportation of these goods.

From the viewpoint of encouraging container shipping of goods with a low average containerization rate, it is essential to reduce export and import costs, including costs related to transport of goods to the port prior to shipment and landing and customs procedures, in addition to maintenance costs relating to port and land-based infrastructure. These measures are also necessary from the viewpoint of reducing imbalances.

CHAPTER 5

DECISION-MAKING STRUCTURE REGARDING THE CHOICE BETWEEN BULK AND CONTAINER TRANSPORT

5.1 Introduction

Previous studies regarding BCC were reviewed in Chapter 3. However, these studies did not address specific BCC decision-making entities, the relationships between those entities, and the structure of the decision-making process. Therefore, in an attempt to identify the optimum BCC promotion policy, the decision-making structure is examined based on interviews with practitioners and a survey of the literature regarding the entities related to BCC.

The decision-makers that were targeted in this research include shipping companies, logistics companies, trading companies, shippers, consignees, and port-related personnel. BCC is one possible transport mode that might be considered as a result of changes in factors such as freight rates, costs other than freight rates, and the characteristics of the cargo. For example, Miyashita (2002) discusses air transport and container transport modes by addressing factors such as freight rates, inventory costs, and product cycle changes. The opportunity cost attributable to logistics compliance is also considered as a factor in mode selection. In this dissertation, the decision-making structure is organized in accordance with the context of such a selection model.

The structure of this chapter is as follows. Section 5.1 outlines the interview survey method. Section 5.2 analyzes the survey results to present a summary of the decision-making factors affecting shipping companies, logistics companies, and shippers, and identifies the primary decision-makers in relation to BCC. Section 5.4 discusses decision-making agents in relation to BCC. Section 5.5 proposes measures necessary to promote BCC and provides a summary of the chapter and conclusions.

5.2 Outline of the Interview Survey

5.2.1 Interviewees

From January to July 2017, personnel from 23 companies in Japan and the US were interviewed. Interviewees were chosen not only from shipping companies, but also from other related organizations. The Port of Los Angeles/Long Beach in California is responsible for the largest volume of BCC in the world, and was targeted on the assumption that it would contain people with considerable knowledge of BCC.

The breakdown of the interviewees in Japan is as follows: six shipping companies, three forwarders, two consignees, two container leasing companies, one industry newspaper reporter, and three trading companies. With the cooperation of Japan Shipowners' Association, an experienced representative from the container section coordinated the interviews with Japanese shipping company personnel, who also collected answers from foreign and logistics subsidiaries of each company. The other respondents were interviewed individually. In non-Japanese shipping companies, Japanese sales staff were the main respondents, and in forwarding companies, the person in charge of maritime freight responded. In trading companies, people involved in the bulk transport of crops and pulp products responded. The consignee respondents were people involved in the procurement of raw materials for the manufacturing industry and people experienced in the logistics of crop freighting. Experienced representatives from container leasing companies responded. Finally, the industry newspaper reporter was investigating trends in the trade of scrap metal.

The breakdown of the organizations represented by interviewees in California in the US is as follows: one forwarder, two port administrators, one terminal operator, one container transloading company, and one scrap trading company. Representatives of the Japanese shipping companies, in particular Mr. Hirotaka Akaiwa of Shipfan, helped to make appointments with respondents in the United States. The respondent from the forwarder mainly handled cargo related to Japan and Korea, and had considerable experience in Asia prior to working in the US office of the shipping company. The port authorities were the managers of the marketing departments of the Port of Los Angeles and the Port of Long Beach. The respondent from the terminal operator was in charge of the bulk transport division. The respondents from the container transloading company and the scrap trading were interviewed on site.

5.2.2 Survey Questions

The main questions were related to the general status of BCC and decision-making, and information on BCC and its future. The questions are summarized in Table 5.1 and the full questionnaire is presented in Appendix IV. Some questions were changed in response to either the status of respondents or their replies. Moreover, following the review presented in Chapter 2 and the literature survey presented in Chapter 3, documents relating to containerization and bulk transportation were examined prior to the interviews, and various issues that were contained therein were reflected in the questions that were asked. They were also used to complement the responses when summarizing BCC promotion measures.

Table 5.1 Main Questions in the Survey

General status of BCC	**Decision-making agent and information collection regarding BCC**	**Future of BCC**
Commencement time	Decision-making agent	Optimism regarding BCC
Main consignees of containerized cargo	Factors in decision-making	The possibility of promoting BCC through automation, digitization, and innovations in container shipping
Main types of containerized cargo	Sequence of mode choice	Challenges to promoting BCC
Benefits and disadvantages	Change of contracts through BCC	
Differences between bulk shipping and container shipping	Opportunities for acquiring information regarding BCC	

5.3 Decision-Making Factors Regarding BCC

5.3.1 Decision-Making Factors of Interest to Shipping Companies / Logistics Companies / Shippers / Consignees

Respondents representing shipping companies, logistics companies, and consignees commonly cited leadtimes, freight rates, cargo handling costs, inventory costs, procedural costs, item characteristics, and cargo values as factors affecting their choice between bulk shipping and container shipping. This is consistent with the standard mode selection criteria described earlier.

Leadtimes and freight rates were the most significant factors in transport mode selection, being cited by 17 of the 23 respondents. Because it is faster and more frequent, container transportation usually offers a shorter leadtime and greater punctuality. Bulk carriers cannot depart without a full cargo, and often have to wait to enter ports to either load or unload their cargo. Regarding freight rates, container shipping companies sometimes offer a very low rate for bulk cargo instead of transporting empty containers. Some shipping companies term this "equipment control[33]," and use it to collect cargo from backhaul exporters that are located near mainhaul importers in places where it is difficult to obtain backhaul cargo. Meanwhile, container shipping companies and forwarders were concerned about shippers'/consignees' reluctance to pay the transportation costs of containerized bulk cargo[34].

Costs other than freight rates were other commonly mentioned items. Either shippers or consignees pay these costs up front, but eventually they are charged to the consignees. Thirteen respondents commented about cargo handling costs and inland transportation costs. In the case of container shipping, freight rates include port handling costs, and sometimes also include the cost of inland transportation. Usually, when shipping companies or

[33] This method is used to collect cargo from nearby exporters when the importers are located in the outback.

[34] This supposes that shippers and consignees are not prepared to pay transportation costs in excess of a certain percentage of the value of the cargo. In Japan, practitioners term this the "freight rate paying capacity."

forwarders arrange port and inland transportation, shippers or consignees pay the costs of these services.

Meanwhile, FIO contracts are standard in bulk shipping, and shippers or consignees are required to arrange the loading and unloading of the cargo. However, when shippers or consignees can use facilities such as a grain elevator, this does not present a problem. In the case of bulk transport, these costs will be paid by shippers or consignees directly to port transportation companies, trucking companies and owners of bulk facilities.

The cost of vanning /devanning is another cargo handling cost. For goods that are difficult to pack, shippers and consignees need the facilities and equipment necessary for vanning/devanning. For example, when some woods are packed into a container, a molding process may be necessary, and when liner bags are used to carry goods like cereals, the cost of the liner bags[35] and the filling/discharging device must also be borne. Even with scrap metals, container loaders[36] and container tilters are needed (see Figure 5.1).

Figure 5.1 Container Loader (left) and Container Tilter (bottom right)

Sources: A-WARD

[35] A liner bag is a disposable inner pouch used for carrying goods that are difficult to pack into a container such as powders and liquids. When vanning, the liner bag is placed inside the container before being filled. For devanning, the container is tilted, the liner bag is sliced open using a special cutter, and the contents are removed.

[36] A container loader is a device that consists of a box with a hole in the upper surface that is used to pack bulk cargo into a container, and a container tilter is a device that enables containers to be loaded and unloaded by being tilted to one side.

Seven respondents mentioned inventory costs. Since bulk transport carries a significant amount of cargo in one shipment, inventory maintenance costs are higher. Expensive facilities such as silos and elevators are necessary for cargo storage. Inventory interest costs[37] are also higher for bulk transport (Rodrigue, 2017).

Six respondents mentioned procedural costs including customs clearance fees and other document submission expenses. In the case of bulk transport, many countries allow the shipment to clear customs while cargo handling is underway, and some respondents noted that this was more flexible and straightforward. Conversely, in the case of container transport, multiple procedures are necessary because numerous transactions are involved. Moreover, the customs clearance procedure is stricter, and all documents including those relating to cargo handling permissions, quarantine certificates, and tax payments have to be submitted before the arrival of the ship. In addition, there is a cutoff point beyond which acceptance by container yards and container freight stations (CFSs) ceases.

Table 5.2 Import Costs in Various Regions (USD/container)

	East Asia & Pacific	Europe & Central Asia	Latin America & the Caribbean	Middle East & North Africa	South Asia	Sub-Saharan Africa	OECD High Income	Tokyo
Costs for border compliance such as customs clearance	431.0	185.1	684.0	540.7	638.0	686.8	111.6	275
Costs for documentary compliance	111.4	94.7	119.5	266.2	341.6	300.1	25.6	107

Source: World Bank's "Doing Business" 2018 report

Note: The cargo is automobile parts in 15-ton containers and the data are for the period until June 2017.

In the case of trade with developing countries, there is a possibility that procedural costs may be higher as a result of unclear criteria based on the original system and the need to use paper documents as a result of delays in installing ICT-based systems. As can be seen from Table 5.2, the import cost for containerized cargo is 137.2 USD (=111.6+25.6) per container in

[37] This refers to interest on funds raised to purchase inventory.

developed countries and even higher in developing countries. Investigations by Maersk and IBM in September 2016 found that of the 2,000 USD charged for the transportation of each container from Mombasa to Rotterdam, 300 USD was for expenses such as customs clearance procedures (Groenfeldt, 2017).

Two respondents also mentioned demurrage costs. Demurrage is a charge that is payable if the cargo has not been loaded or unloaded prior to the scheduled departure time, and is applicable to tramp vessels including bulk carriers. When the agreed departure time is passed, the shipping company incurs dwelling charges. Conversely, shippers or consignees receive a premium when the ship departs before the agreed departure time. Because the demurrage status is unknown to shipping companies, shippers, and consignees in advance, they are uncertain about payments/receipts.

Characteristics of goods were also cited as a decision-making factor. Ten respondents mentioned item characteristics of material aspects. Besides the ease of packing described above, the ease of preservation is also relevant to decision-making. In the case of bulk shipping, the large quantities of cargo carried and the longer leadtimes mean that damage tends to be worse. Thus, preservation becomes more important. Container shipping involves smaller transportation quantities and shorter leadtimes, and thus there are less preservation problems. However, humidity and temperature management are essential in the containerized transportation of crops (Lirn, 2017).

Nine respondents cited market characteristics. The opinion was expressed that containerized transportation is suitable for goods that depend on spot transactions and for which trends are too unreliable to predict demand fluctuations. Since it is difficult for traders of goods that are dependent on spot transactions to hedge against price fluctuations, the risks attached to bulk transport tend to be greater. In addition, goods for which demand fluctuates have a higher level of inventory risk. However, small-lot shipping can reduce these risks. Moreover, goods that involve numerous small consignees are suitable for container shipping.

5.3.2 Decision-Making Factors that are Mainly of Interest to Shipping Companies

Eight respondents, mainly from shipping companies, cited concerns about damage to containers as a factor in decision-making. Bulk cargo may cause damage to containers and contamination to both containers and ships[38]. Containers are mainly owned by shipping companies and leasing companies, and shippers or consignees are usually responsible for any damage or contamination[39]. However, they do not always meet their obligations. Therefore, there is concern about problems in relation to liability when leakage of cargoes such as liquids and powders causes damage to containers and ships[40].

Seven respondents mentioned issues regarding imbalances and cargo weight. There is a weight limit of about 20 tons for 20-foot containers and about 25 tons for 40-foot containers, and goods with low specific gravity can be fully packed within these weight limits. However, bulk cargo tends to have a very high specific gravity, and even if cargo is loaded to the weight limit, there is often still space inside the container. Further, if all containers are loaded to their weight limits, it might not be possible to fill all the container slots on ships without exceeding their deadweight limits. Shipping companies are also concerned about fully weighted vessels carrying empty containers.

Six respondents mentioned the difficulty of procuring containers. BCC often requires numerous containers, and shippers/consignees are sometimes required to procure up to 100 containers, causing difficulties in both procurement and operations. However, this problem

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[38] Scrap metals and wood/steel materials may damage containers, and waste paper may be dirty. Cereals, chips, and hay can enter gaps in containers. Because leather attracts salt water, odors and moisture may remain in the container.

[39] Regarding container damage, respondents from some shipping companies commented that they always clarify who is responsible for damage and assure customers in writing that they will identify the perpetrator in the case of damage to a container. Moreover, they take pictures of the container in advance so that they can track its condition.

[40] When the leaked goods are dangerous, the risks are increased. There is also a risk of explosion as a result of the inclusion of dangerous goods in shipments of scrap metals. There have also been cases where weapons and refugees have been found in containers.

can be overcome by establishing transloading facilities near places where there are many types of imported cargo and using empty containers for export cargo (Rodrigue, 2017).

In addition, four respondents pointed out the need for expertise in handling, packaging, and storage facilities for dangerous goods, and in preparing facilities to handle them. Two respondents also mentioned the problem of cargo abandonment. This refers to the risk that containers are not collected at the destination port or container depot because many consignees are unknown small and medium-sized enterprises, and may not arrive to collect their cargo.

One respondent also mentioned a problem regarding retention of containers in importing countries as a result of system changes and tightening of regulations. If cargo is inspected under the regulations of the importing country, there may be a risk of interference in the activities of other shipping companies in the same shipping alliance. For example, one respondent from a shipping company stated that Chinese authorities tightened the regulations in 2013 because garbage was being brought into the country in containers, and commencing in 2018, China started to regulate the importing of recycling goods such as waste plastics and paper (Kako, 2018). This has already affected trade in these goods, and some containerized imports to China have ceased. Conversely, regulatory developments may support BCC. One example is in relation to Australian grain exports. Since 2008, when grain trading was deregulated in Australia, containerized wheat shipments have increased tenfold (UNCTAD, 2013).

5.3.3 Decision-Making Factors that are Mainly of Interest to Consignees

Three respondents mentioned frequency and punctuality of shipments as important factors in decision-making by shippers. Container transportation is more frequent and punctual than bulk transport. It is not unusual for shippers to be forced to wait for up to a month to obtain bulk transport in peak seasons such as the grain harvesting period in South America.

In addition, three respondents mentioned exchange rate fluctuations. Favorable rates encourage the use of containerized transport because changes in exchange rates can increase the amounts due for cargo, freight, and other costs.

Two respondents also mentioned theft as an issue for concern among consignees. Bulk cargo is transported in trucks that may not be sealed during inland journeys, and may also be exposed during handling at the port, increasing the likelihood of theft.

5.4 Main Decision-Making Agents in Relation to BCC and their Behavior

To summarize the above discussion, the main decision-making agents in relation to BCC are shipping companies, logistics companies such as forwarders, shippers, and consignees[41]. Shipping companies and forwarders were advised that there was a possibility of BCC at port seminars and through inquiries from shippers and consignees. Although some shipping companies undertake aggressive sales activities, most container shipping companies only propose containerized shipping as an option for shippers/consignees to consider, while forwarders also tend to be passive regarding BCC, only responding to inquiries.

A forwarder pointed out that it is necessary for consignees to accept BCC, while a consignee noted that consignee-led BCC such as the transport of non-GMO soybean imports to Japan was evident. In addition, a consignee and a shipping company representative both mentioned that consignees are involved in the choice of the means of transport as part of the management plan. A port authority marketing director pointed out that consignees make the final decision on the demand side of the supply chain. There is also a view that BCC has developed in line with the changing needs of consignees (Matsuda and Kawasaki, 2013). Moreover, trading companies should also be regarded as consignees. Thus, it is clear that consignees lead decision-making in relation to BCC. This is consistent with the findings of Lirn *et al.* (2013), who based their analysis on the assumption that consignees make decisions regarding BCC.

[41] Terminal operators are also involved, but they operate in response to requests by shipping companies.

In addition to financing, some interviewees pointed out that procurement of equipment and changes in contracts needed to be taken into account by consignees as part of their decision-making process. Regarding financing, cargo procurement costs and freight rates for containerized shipping are relatively small because the volume of cargo per shipment is smaller than for bulk shipping (Mongelluzzo, 2007). Since funds used for bulk transport can also be used to fund BCC, the problem of finance is not significant in the initial stages. However, total transport costs over a specified period (for example, one year) tend to be greater for container shipping, and thus additional finance is required over the medium to long term. As for equipment procurement, it is necessary to procure container loaders and other equipment necessary for container handling. Cereals and raw materials also require the purchase and disposal of packaging equipment such as container liners. Further, if a consignee has invested in a large-scale bulk port facility such as a silo and elevator, it will not be possible to recoup the investment cost, let alone obtain a return on the investment, if BCC is adopted because the consignee will no longer require the facility, hence a switch to BCC is unrealistic.

Regarding contract changes, BCC usually involves a change in the contract held with shipping companies. In the case of bulk transport, the shipping contract may be via a trading company or a broker, but in many cases the shipping company and shipper form a direct contract. In the case of container shipping, this is often arranged through forwarders, rather than directly with the shipping companies. However, interviewees stated that the change in contract partner was not fundamental to the failure of BCC. In addition, because the types of trucks that are required to transport the cargo to and from ports differs between bulk shipping and container shipping, there is a possibility that consignees will need to change their contracts with trucking companies.

Moreover, once the change is made to BCC, a return to bulk transportation cannot occur until sufficient cargo is accumulated as noted before. BCC differs from the containerization of air cargo in that BCC involves a commitment that lasts for months.

5.5 Summary of the Survey Questionnaire and Chapter Conclusion

Other than practitioners who were actively involved in bulk transport such as forwarders and trading companies, the respondents all agreed that BCC could contribute to increasing container cargo volumes. Although BCC is not new, having commenced in the 1980s, some representatives of shipping companies and port authorities indicated that they would like to see an increase in BCC as one source of new cargo. However, most respondents emphasized that the choice of transport mode must obey economic principles. Based on these responses, Figure 5.2 shows a conceptual diagram summarizing the factors encouraging decision-making that promotes BCC.

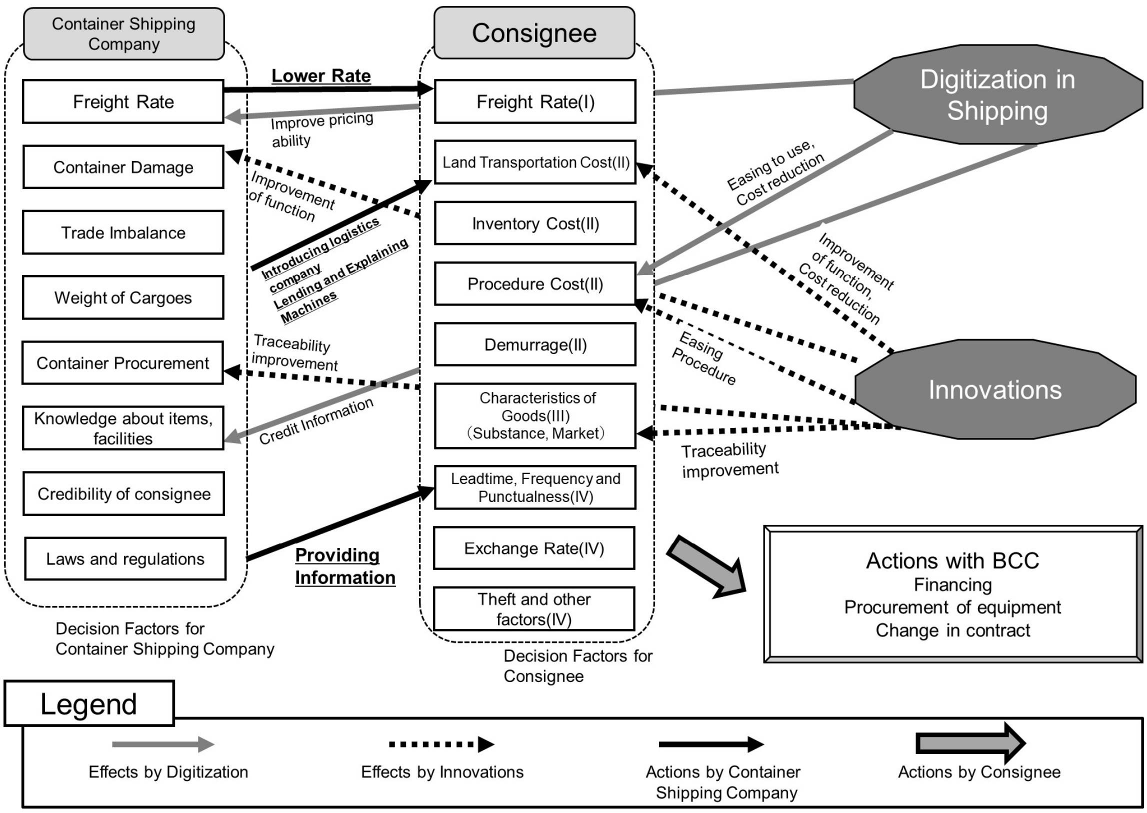

Figure 5.2 Decision-Making Factors Encouraging the Promotion of BCC

Solid gray arrows represent the influence of environmental changes (e.g., digitization), black dotted arrows represent innovations, actions by container shipping companies toward consignees are represented by solid black arrows, and shippers' actions are represented by thick arrows. In addition, to correspond to the factors influencing general transport mode selection, the decision-making factors for consignees are classified into (I) freight rates, (II) costs other than freight, (III) item characteristics, and (IV) other factors.

First, in terms of what shipping companies can do to promote BCC, a reduction in freight rates is essential. One shipping company representative emphasized that the critical factor in promoting BCC is the ability to offer low freight rates to bulk cargo customers. Here, it is important not to measure profitability in terms of cargo carried in one direction, but to maximize profit on the round trip, even if the freight rate for returning bulk cargo is low. Conversely, in relation to mainhaul cargo, it may be necessary to collect an imbalance surcharge[42] and to consider flexible freight rates in response to the difficulty of alleviating imbalances.

Regarding reductions in transportation costs, it is essential to keep costs other than freight rates as low as possible through innovations that cut cargo handling costs in relation to packaging, port handling, and inland transportation and equipment such as vanning and devanning. Moreover, it is necessary to improve the quality of equipment. Thus, to encourage progress, it is worth considering cooperation with equipment manufacturers. Advances in cargo handling equipment were a key factor in the progress of BCC in the latter half of the 2000s (Matsuda and Kawasaki, 2013), although some interviewees pointed out that there is considerable room for improvement in liner bags in terms of quality preservation and cost. Improvement in liner bags is also important for reducing container damage. There are also ways to reduce the cost of introducing new cargo handling equipment. A shipping company representative said that the company lends loading/unloading equipment to customers and teaches them how to use it until the customers are fully trained in using the equipment. This also serves to reduce the introduction and learning costs for shippers and consignees.

Another important factor is a reduction in the cost of procedures such as digitization. As of 2018, some efforts are aimed at reducing procedure costs by digitizing trade procedures using

[42] One interviewee stated that shipping companies occasionally collect an imbalance surcharge.

blockchain technology. Digitizing the transaction history not only allows for flexibility in setting freight rates but also helps to avoid container damage and dealing with shippers with low levels of credibility. Further, simplification of customs procedures using innovations such as IC tags is also useful in achieving cost reductions. Improved traceability of containers using this type of technology also contributes to alleviating the problem of container procurement faced by shipping companies.

Apart from cost reduction, it is also necessary to aim for cargo collection based on item characteristics. For example, it is worth considering cargoes that have particular characteristics, such as “identity preserved” grains, for which traceability is essential, and cargoes that are located in areas where they can be only be carried by container because there are no ports with bulk cargo handling facilities. In addition, it is worth considering container shipping companies actively promoting BCC by arranging and introducing inland carriers to consignees and providing information regarding BCC such as leadtimes, frequency, punctuality, inventory costs, and risks.

CHAPTER 6

COST ANALYSIS OF BULK CARGO CONTAINERIZATION

6.1 Introduction

This chapter explores the behavior of consignees and container shipping companies when selecting the transportation mode. In Chapter 5, the decision-making mechanism was examined based on interviews with practitioners. A primary objective of this dissertation is to assess whether decision-makers have economic incentives to adopt BCC. Thus, this chapter presents an assessment of the behaviors of consignees and container shipping companies regarding BCC based on the findings presented in Chapter 5.

In earlier chapters, it was shown that a reduction in the costs listed below increased consignees' incentives for choosing BCC (Hypothesis 1): (i) container freight rates, (ii) transport costs other than freight, and (iii) inventory costs. Item (ii) includes (ii-a) loading/unloading costs and inland transportation costs and (ii-b) procedural costs in import countries such as customs clearance costs. This implies that digitization and innovations in container shipping promote the adoption of BCC through cost reductions (Hypothesis 1a).

Conversely, if consignees can use large bulk unloading facilities such as elevators and silos, incentives for choosing BCC are weakened (Hypothesis 2). Further, container shipping companies have an incentive to promote BCC to help mitigate the impact of trade imbalances (Hypothesis 3).

In this chapter, a cost model regarding transport mode choices for backhaul trade is used to examine the incentives for consignees, who are regarded as the primary decision-makers regarding BCC, as noted in Chapter 5, and shipping companies. The model has a relatively simple structure but includes a considerable amount of detail. To date, no model has been proposed that includes detailed information regarding costs and profits to facilitate the choice of routes.

6.2 Decision-making Agents, Costs, and Profits Relating to BCC

6.2.1 Decision-making Agent Behavior

Here, the model used for analysis in this chapter is described. Suppose that a certain amount of bulk cargo is carried from point x in country A to point y in country B. It is assumed that containers can be shipped between country A and country B either direct or via a transshipment port, and shipment from country B to country A is the main route (mainhaul). This means that the container cargo volume on the return route from A to B is less than that on the main route from B to A. Although bulk transport was initially carried out, it is assumed that transportation by container has come under consideration. The container shipping company is considering whether this mode of transportation can be offered, and the consignee is also starting to consider the possibility of selecting a different transport mode. However, as indicated in Chapter 4, if a consignee decides to change from bulk transportation to container transportation, it takes a certain amount of time to accumulate sufficient cargo for bulk transport, and so if the consignee decides to switch to container transportation, it will be some time before they can return to bulk transport if container transportation is unsuccessful. Meanwhile, the shipping company will not be able to carry the bulk cargo in a single container shipment, and so it will need to send several container ships to transport the cargo.

An outline of the analysis is shown in Figure 6.1. In trying to express the BCC decision, it is necessary to formulate a set of decision-makers and a set of options (behaviors) that each decision-maker can choose, and then outline the benefits of each option. Figure 6.1 reflects the results of Chapter 5. First, the main decision-makers regarding BCC are container shipping companies and consignees. Moreover, it seems that the role of logistics companies is similar to that of shipping companies such as forwarders. Second, the leading decision-maker is the consignee. Thus, it is assumed that the decision-making process to select either bulk shipping or container shipping takes a form whereby a container shipping company chooses whether to offer a container shipping service for bulk cargo, and if it does so, the consignee decides whether to accept the offer.

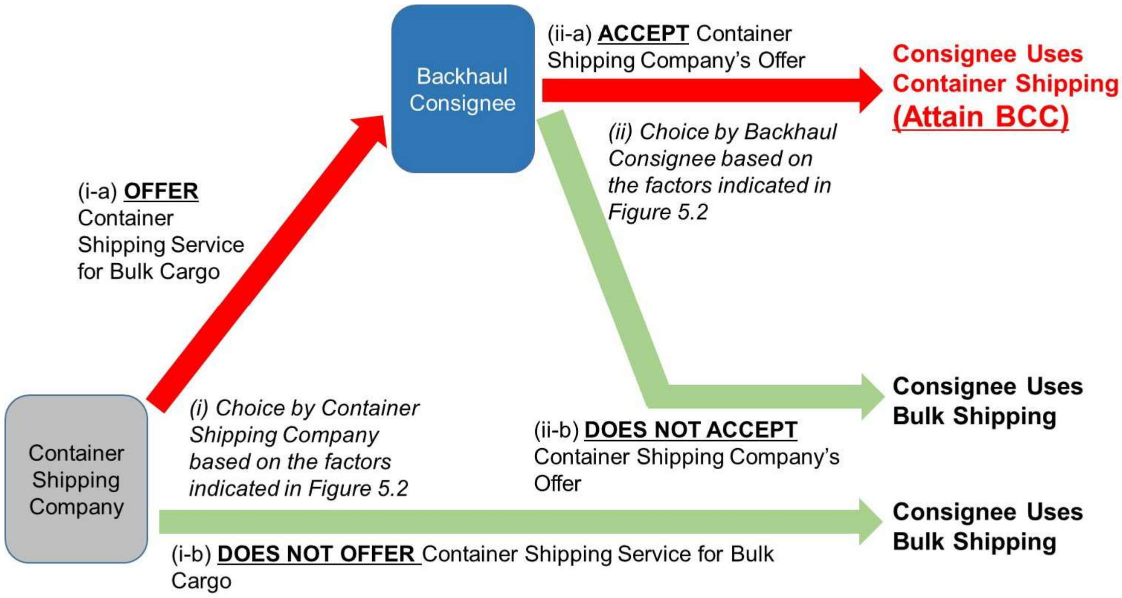

Figure 6.1 Decision-making Process in the Selection of Bulk Shipping or Container Shipping

The consignee's choice between bulk and container shipping is based on the total cost including purchase costs, tariffs, and changes in the value of the goods. Further, the total cost is affected by the factors shown in Figure 5.2 in the previous chapter. Meanwhile, the container shipping company must decide whether to offer BCC based on total profits from both mainhauling and backhauling. It is not always profitable for shipping companies to carry backhaul cargo. In addition, shipping companies' incentives to carry cargo depend on the cost of transporting empty containers back to the loading location, the return freight rate, and whether the destination is a direct source of cargo (Theofanis and Boile, 2009.) Thus, it is crucial to examine the incentives for shipping companies. These are also affected by the factors shown in Figure 5.2 in the previous chapter.

In general, the consignee is regarded as having the ultimate power over the entire supply chain in terms of decision-making regarding the transport mode because they are the source of demand (and payment), as explained in Chapter 5. Therefore, it is considered that consignees lead the choice of transport mode, rather than shippers. In addition, even if the shippers choose the transport mode, consignees purchase imported goods using a specific transport mode, and so shippers cannot ignore the wishes of consignees in deciding on the transport mode.

The results presented in Chapter 5 show that container shipping companies are not proactive in encouraging their customers to select a particular transport mode. Therefore, it is considered that container shipping companies, forwarders, and logistics companies are relatively passive, and regard themselves solely as service providers rather than playing a leading role in promoting BCC. In addition, forwarders sometimes become shippers with container shipping companies, so it can be seen that the container shipping company is mainly engaged in presenting services and information. Further, in discussing BCC, the choice about whether to change to container transport for cargo that is currently transported by bulk carrier is considered, and for the sake of simplicity, the behavior of the bulk shipping company is regarded as given.

It is assumed that the container shipping company decides whether to offer container shipping at a given freight rate. That is, its choices are "(i-a) OFFER a Container Shipping Service for Bulk Cargo" or "(i-b) DO NOT OFFER a Container Shipping Service for Bulk Cargo." It is assumed that the container freight rate is fixed in the analysis undertaken in this chapter. However, it should be noted that this assumption does not necessarily mean that the container shipping company does not offer a different freight rate. It is simply assumed that the current freight rate is mutually understood between the container shipping company and the consignee because the freight rate offered is at a standard level or has already been presented to the consignee. As will be described later, changes in freight offers by container shipping companies can be analyzed in the form of changes in an exogenous variable.

Moreover, for the consignee, it is assumed that he/she decides whether to accept an offer by the container shipping company at a given freight rate. That is, the consignee's choices are "(ii-a) ACCEPT the Container Shipping Company's Offer" or "(ii-b) DO NOT ACCEPT the Container Shipping Company's Offer." In addition, as for the combined use of bulk transport and container transport as mentioned above, it can be interpreted that the consignee is applying a form of mixed strategy from game theory or exhibiting stochastic behavior in deciding on one behavior with a specific probability distribution.

It is assumed that the container shipping company operates a container shipping service along the route considered, and has space available to sell on the backhaul route as a result of a trade imbalance. In addition, it is assumed that if the container shipping company does not offer a service, the backhaul consignee chooses bulk shipping. This means that the container shipping company carries empty containers on the backhaul route, and thus incurs repositioning costs.

It should be noted that the frequency of bulk transport differs from that of container transport. As noted in Chapters 2 and 4, bulk transport carries a large volume of cargo that is to be used over an extended period of time, so even if a consignee that is presently using bulk transport intends to change to container transportation, sufficient cargo will already have been transported for some period into the future. Many companies formulate management plans in units of three months, six months, or one year, and review their long-term management plans annually. Although there are differences in accounting systems and practices among countries and companies, consignees who use bulk cargo transport usually only make decisions once or several times a year. This means that the time frame can extend from several months to several years. Thus, within a given time frame, one load of cargo is transported when bulk shipping is used, while several loads must be transported when container shipping is utilized.

Regarding the volume traded, it is assumed that the consignee intends to import bulk cargo of either 3,000 tons or 28,000 tons per shipment. This means that the consignee either enters into a contract to lease a certain volume in the hold of a general cargo ship (break-bulk ship) when the cargo weight is 3,000 tons or charters a bulk carrier when the cargo weight is 28,000 tons. It is assumed that 40-foot containers are used for container shipping, and the weight per container is calculated based on IHS Markit’s World Trade Service data for 2017.

Further, it is assumed that one truck can carry one container or the equivalent amount of bulk cargo, and thus trucking costs are the same for bulk and container shipping given the same weight of cargo. Regarding the terms of trade, it is assumed that either FOB or Free Carrier (FCA) is used and the shipper arranges and pays for loading the ship in the exporting country. This assumption simplifies the cost calculations because inland costs in the exporting country can be basically included in the purchase costs.

6.2.2 Consignee's Cost Structure

The sum of transportation costs indicates the consignee's cost of purchasing the imported goods. In the analysis undertaken in this chapter, the total cost of international transportation is defined as the sum of all expenses incurred, including the purchase price of the imported goods. Tsuboi *et al.* (2010) considered that the total cost of international transportation could be divided into "transportation expenses," "cost of the change in the value of the goods," and "inventory costs." This division is used to calculate the cost of purchasing tradable goods here. The total costs incurred by the importer when bulk transportation is selected are given by the following equation (the subscript B indicates that the consignee chose bulk transport):

$$TC_B = C_{YB} + C_B + FC_B + SPC_B, \tag{6.1}$$

where C_{YB} represents the total purchase cost (in USD), including insurance costs and tariffs, C_B represents the transportation costs for bulk shipping, FC_B represents the cost of a change in the value of the goods, and SPC_B represents the inventory cost.

The transportation cost for bulk shipping, C_B, is the total of C_{AB} (the charter rate for the voyage), C_{BB} (the land transportation and unloading costs), C_{CB} (the cost of procedures such as customs clearance), and C_{DB} (depreciation of facilities such as silos and the cost of renting unloading equipment). The charter fee is in USD because it is settled in USD. Other costs are also expressed in USD for ease of calculation.

The cost of the change in the value of the goods, FC_B, is given by:

$$FC_B = p\left(days_B + \frac{T}{2}\right)\left(\frac{r}{100\cdot 365} + \frac{CV}{100}\right), \tag{6.2}$$

where p represents the purchase cost plus added value (i.e., the total sales value), $days_B$ represents the leadtime for bulk shipping, T represents the time frame (in days), r represents the interest rate, and CV represents the change in the value of the goods transported.

The inventory cost, SPC_B, is given by:

$$SPC_B = \left(\frac{V}{2} + k\sigma\sqrt{days_B}\right)SC, \tag{6.3}$$

where SC represents the unit cost of storing the inventory, k represents a safety factor coefficient (assume that $k = 1.65$ [43]), σ represents the standard deviation of demand for the goods traded, and V represents the volume of goods to be carried.

The total costs incurred by the consignee when container transportation is selected are given by the following equation (the subscript C indicates that the consignee chose container shipping). It should be noted that when container shipping is used, several trips will be required to carry the same amount of cargo as a single bulk load, and so these costs will be incurred several times.

$$TC_C = \sum_{t=1}^{n}\left(C_{YCt} + C_{Ct} + FC_{Ct} + SPC_{Ct}\right), \tag{6.4}$$

where C_{YCt} represents the cost of purchasing the imported goods including insurance costs and tariffs, C_{Ct} represents the transportation cost for container shipping, FC_{Ct} represents the cost of responding to a change in the value of the goods, SPC_{Ct} represents the inventory cost, and n indicates the number of shipments that are required to carry the equivalent of a bulk cargo shipment.

[43] When the demand varies based on the normal distribution $N(\mu,\sigma)$, the probability of a shortage is expressed as a function of the demand quantity. Conversely, if the probability of a shortage is assumed, the quantity can be calculated using this probability function. If the probability of a shortage is set at 0.05, the demand quantity is calculated as $\mu + 1.65\sigma$. Thus the probability of a shortage is 0.05 and $k = 1.65$.

C_{Ct} is the total of C_{ACt} (container freight rate for the backhaul route), C_{BCt} (land transportation and unloading costs), C_{CCt} (the cost of procedures such as customs clearance), and C_{DCt} (depreciation of facilities such as silos and the cost of renting unloading equipment).

The container freight cost is expressed in USD based because it is settled in USD. Other costs are also expressed in USD for ease of calculation. It is assumed that C_{Ct} is constant over time. The cost of changes in the value of the goods traded, FC_{Ct}, and the inventory cost, SPC_{Ct}, are in the same form as the formulas presented in equations (6.3) and (6.4), respectively, the only changes being the subscripts and the suffix *t* regarding the number of times container transport is required.

6.2.3 Profit Structure of a Container Shipping Company

A container shipping company earns profits from the service it provides. The round-trip profit is calculated by subtracting the costs of providing shipping services from the revenue received through freight rates. The reason for considering the round trip is that it is a selection criterion for either establishing or maintaining a container shipping route regardless of whether the round trip is profitable, and it is also a criterion in the decision on whether to accept transportation requests. The round-trip profit is given by the following equation when the container shipping company offers to provide containerized transportation of bulk cargo:

$$\pi_1 = \pi_{Main} + \pi_{Back}, \tag{6.5}$$

where $\pi_{Back} = \sum_{t=1}^{n} \left[C_{AMt} - COST_t - pr_1 DAM_t - pr_2 \left(C_{ACt} + C_{AMt} \right) - pr_3 DET_t \right]$

and $\pi_{Back} = \sum_{t=1}^{n} \left[C_{ACt} - COST_t - PRO_t - pr_1 DAM_t - pr_2 \left(C_{ACt} + C_{AMt} \right) - pr_3 DET_t \right]$,

where π_1 is the total profit from the round trip, given by the sum of π_{Back} (backhaul profit) and π_{Main} (mainhaul profit) for each period *t*, $COST_t$ represents the operational cost per shipping container, PRO_t represents the container procurement cost, DAM_t represents the container repair cost, C_{AMt} represents the container freight rate for the mainhaul container route from B to A, DET_t represents the cost of the containers remaining in the destination country for too long, pr_1 represents the probability that the container is damaged, which is positively correlated with cargo weight, pr_2 represents the probability that the container is not collected (i.e., the cargo is abandoned), and pr_3 represents the probability that the container remains in the destination country for too long, which is affected by the credibility of the consignee and the local regulations. It is assumed that there are no fluctuations in operational costs or any other related costs over time.

Conversely, profit from not engaging in containerized transport of bulk cargo (either because the service is not offered or it is offered but no orders are received) is given by:

$$\pi_2 = \pi_{Main} - \sum_{t=1}^{n} IMB_t \, , \tag{6.6}$$

where $IMB_t = COST_t - OTHC_t - DTHC_t$ represents the container repositioning cost, $OTHC_t$ represents the terminal handling charge at the port of origin, and $DTHC_t$ represents the terminal handling charge at the destination port.

Equation (6.6) is similar to the second term on the right-hand side of equation (6.5), the only exception being the container return cost, IMB_t. This reflects the fact that if the container shipping company did not receive orders for containerized shipments of bulk cargo, it would have to return the containers to their original location at its own expense.

6.3 Conditions Necessary to Realize BCC

To realize BCC, the container shipping company must have an incentive to offer a containerized shipping solution, while at the same time the consignee must have an incentive to use containerized shipping.

For the container shipping company, this means that it will only offer a containerized shipping solution for bulk cargo if this will prove more profitable than not offering this service. This can be expressed by subtracting equation (6.6) from equation (6.5) as follows:

$$\pi_1 - \pi_2 = \sum_{t=1}^{n} \left[C_{ACt} - PRO_t + OTHC_t + DTHC_t - pr_1 DAM_t - pr_2 \left(C_{ACt} + C_{AMt} \right) - pr_3 DET_t \right] > 0 \,. \quad (6.7)$$

Therefore, BCC can be promoted by increasing the freight rate and reducing the cost of container repairs, procurement, and retention costs in the destination country. In addition, the lower the probability of container damage, refusal to receive containers, and overstay as a result of inspections, the lower the cost of providing a containerized shipping solution for carrying bulk cargo.

The condition for consignees can be expressed as $TC_B > TC_C$. This means that total logistics costs including purchase costs for container shipping are lower than those for bulk shipping. This is illustrated in Figure 6.2.

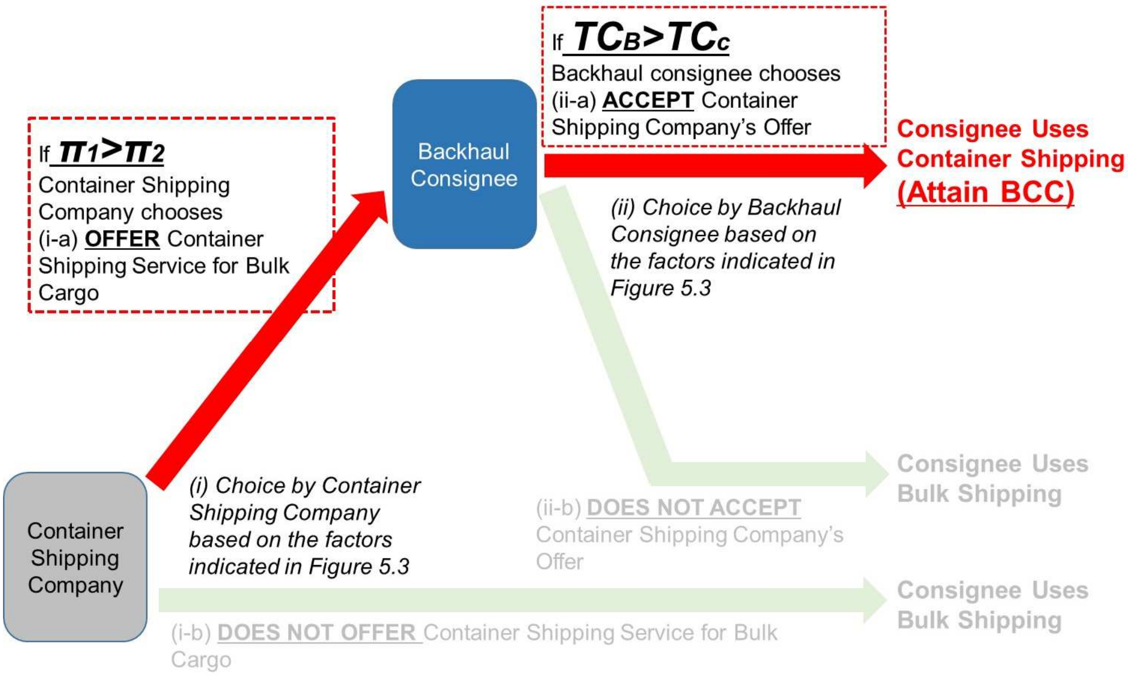

Figure 6.2 Conditions for Realizing BCC

6.4 Data Analysis

Here, an analysis is conducted of what is needed to establish the conditions whereby $TC_B > TC_C$ and $\pi_1 > \pi_2$. Several input variables need to be prepared to estimate the incentives for each shipping type using this model. Input values are all exogenously given. The process of data preparation is outlined as follows.

Routes from Houston, Los Angeles, Santos, Rotterdam, and Yokohama to Shanghai and Yangon, as shown in Figures 6.3 and 6.4, are used for the analysis. It is assumed that no transshipment occurs for routes to Shanghai, but transshipment takes place in Singapore for routes to Yangon. Goods considered are Recycling Items (Ferrous Scrap (HS 7204) and Waste Plastics (HS 3915)), Grains (Oilseeds (HS 1204–1207) and Soybeans (HS 1201)), Chemicals (Organic Chemicals (HS 29) and Inorganic Chemicals (HS 28)), and Metals (Flat roll (HS 7208–7212) and Aluminum (HS 76)).

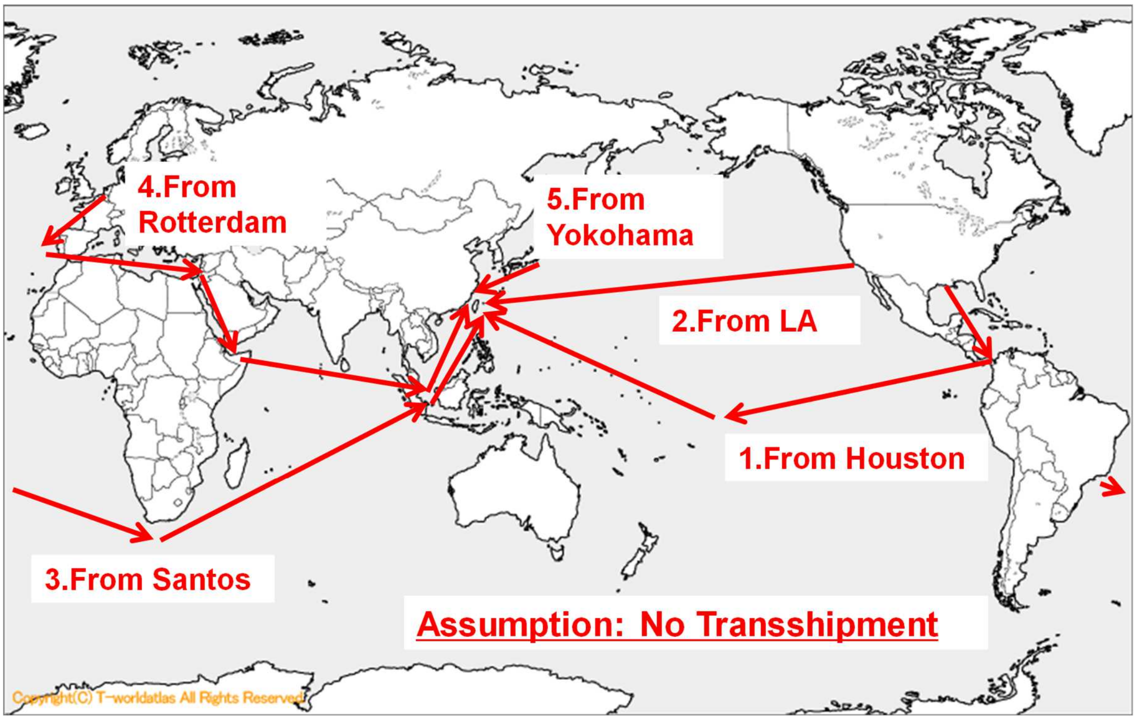

Figure 6.3 Routes to Shanghai

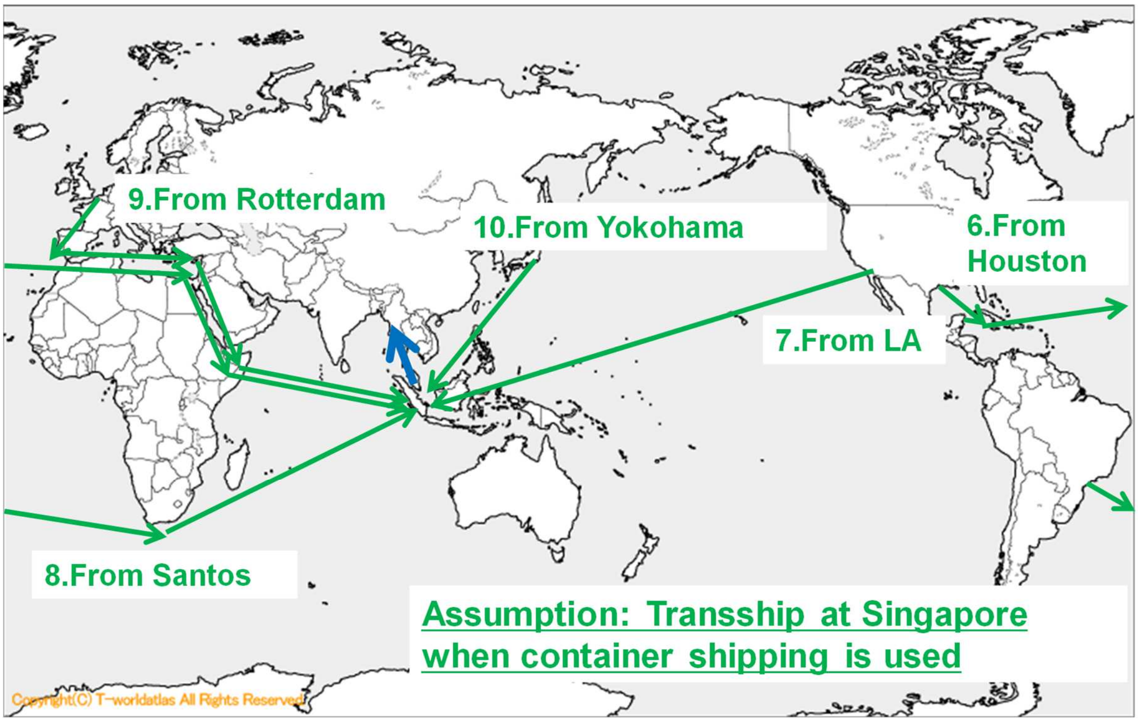

Figure 6.4 Routes to Yangon

The analysis assumes that the consignee imports 3,000 tons per period using 10 routes × 8 goods – 4 shipments (grain exports from Japan) = 76 patterns. Grain exports from Japan rarely occurred, and thus were ignored. In addition, the analysis considers the case in which the consignee imports 28,000 tons per period using 8 routes × 1 good (soybeans) = 8 patterns.

Data used to calculate the consignee's costs are shown in Table 6.1. These data were collected in 2017. In cases where historical data were difficult to obtain, the latest values were used.

The purchase cost of goods under FOB conditions used for calculating the total unit cost is based on trade statistics. Therefore, the analysis used the total export value in 2017 as the purchase cost, and the total unit cost is expressed as the total cost per ton. US export data are from Datamyne, European data are from Eurostat, Japanese data are from the Ministry of Finance trade statistics, and Brazilian data are from the UN's Comtrade database. The cost of purchasing goods is assumed to be the same for both bulk and container transportation. In addition, it is assumed that the price remains constant in any period *t*. This assumption may be interpreted as reflecting the fact that consignees fix the purchase price by using futures or some other form of risk hedging to protect them from price changes.

Tariff rate data are calculated using FedEx's WorldTariff database and is based on the average tariff rate per item code for China and Myanmar. Insurance premiums are based on the rates for containerized and bulk transport listed on the World Freight Rates website, and are calculated by multiplying the CIF price by 1.1 times the insurance premium rate. This formula is widely used in the industry. IHS Markit's World Trade Service data were used to calculate the amount of cargo that could be packed into containers in 2017.

The average 2017 value was used to determine the shipping freight rate. The container freight rate was based on Drewry's Container Freight Rate Insight, while the terminal handling charge (THC) was obtained from the MOL Corporation website. Since container freight rates between Singapore and Myanmar are not included in Drewry's data, the latest data were extracted from World Freight Rates in June 2018.

However, because the average general shipping cargo freight rates for 2017 were not available, the latest freight rates published by World Freight Rates were used for the calculation. Further, the rates published by World Freight Rates tend to be higher in situations where there are no semi-liner routes. Hence, freight rates are calculated based on the Los Angeles–Shanghai route, adjusted in proportion to the relative distance. It should be noted that even if the port does not have a semi-liner route, general cargo ships visit the port in response to requests from shippers/consignees. Since distance is a key factor in determining freight rates, this assumption in relation to calculating the freight rates for general cargo shipping seems reasonable. The bulk carrier freight rate is based on the Clarksons Research SIN 2010 database using the Handysize trip charter rate. Freight rates per tonnage of cargo under trip charter are higher than those under a time charter contract. However, consignees are not required to pay fuel costs under a trip charter contract.

Table 6.1 Data used for Consignee Cost Calculations

	Data Source	Notes
Purchasing Cost Components		
Unit Cost	Datamyne, Eurostat, UN Comtrade, MOF "Trade Statistics"	Total export values and weights in 2017 are used for calculating unit costs
Tariff	FedEX "WorldTariff"	Latest Information
Insurance Cost	World Freight Rates	Latest Information (=CIF price*1.1*rate)
Freight Rate Components		
Container Freight Rate and Terminal Handling Costs	Mitsui O.S.K. Lines, Drewry's "Container Freight Rate Insight", World Freight Rates	Average of 2017 except data from World Freight Rates
Freight Rates for General Cargo Ships	World Freight Rates	Freight rate for routes from Los Angeles to Shanghai is base of freight rate calculation, and proportional to distance
Charter Rates for Bulk Carriers	Clarksons Research	Handysize Trip Charter Rate
Unloading/Inland Transport Cost Components		
Port Facility Charges (China)	China Shipping Agency Management	Calculated from tariff rates regarding port labor
Labor Costs and Devanning Costs (China)	China Shipping Agency Management	Calculated from tariff rates regarding port labor
Port Facility Charges (Myanmar)	Elaborated by the author	Calculated by multiplying the ratio of PPP-based per capita GDP between China and Myanmar using IMF World Economic Outlook Database
Labor Costs and Devanning Costs (Myanmar)	Elaborated by the author	
Cost of Truck Transport	World Bank "Doing Business"	Per shipment
Procedural Cost Components		
Cost of Customs Clearance	World Bank "Doing Business"	Cost to import: clearance and inspections required by customs authorities
Cost of Other Procedures	World Bank "Doing Business"	Cost to import: documentary compliance
Inventory Cost Components		
Rent of Silos	Elaborated by the author	Based on silos in Tianjin and Yangon
Unit Rent of Warehouse	JETRO	Based on rent of industrial park in Shanghai and Yangon (m^2/month)
Time Components		
Traveling Time for General Cargo Ships and Bulk Carriers	AXS Alphaliner	Based on an average speed of 12.5 knots
Leadtime for Container Shipping	Freightos	Latest information
Unloading Time for General Cargo Ships and Bulk Carriers	Japanese Shipowners' Association	Based on 50 tons/hour
Trucking Time	Assumption	One day

Transportation costs other than freight rates excluding inventory costs include port facility usage fees, labor costs, and devanning costs, which are classified as cargo handling costs. Regarding the port facility usage fee, tariffs for the use of port facilities were obtained from the China Shipping Agency Management website. Regarding general administrative expenses, the tariff for harbor handling was calculated based on data from the same website. Facility usage fees and labor costs in Myanmar are calculated using relevant figures for China adjusted by the ratio of per capita GDP for China and Myanmar published on the IMF World Economic Outlook database. The silo usage fee was based on the total cost of construction of the silo built in Tianjin in 2015 and the silo that is planned to be built in Thilawa. Depreciation charges assume a useful life of 20 years, a residual value of 10%, and an interest rate of 5%. The silo usage fee was based on three months of amortization. Further, warehouse rents (m^2/month) for industrial parks in Shanghai and Yangon were used to obtain the warehouse rent per ton.

Data from the WB's Doing Business database were used to calculate customs clearance costs, procedure costs, and trucking costs. For the cost of customs clearance, Cost to import: clearance and inspections required by customs authorities data were used, while for the cost of other procedures, Cost to import: documentary compliance data were used. Since these costs are per shipment, they were multiplied by ten to reflect the number of container shipments. In addition, because it is assumed that one truck can carry one 40-foot container or the equivalent weight of bulk cargo, the trucking fee is the same for container and bulk transportation.

Leadtime for general cargo ships and bulk carriers is based on AXS Alphaliner's distance database. Moreover, the speed of bulk carriers was assumed to be 12.5 knots. Since various forwarders and container shipping companies indicate the leadtime or schedule for each route in relation to containerized transport, there is no need to calculate the leadtime based on distance and speed for container shipping. Therefore, leadtimes for container shipping are based on quotations provided by forwarders, with the shortest leadtimes published by Freightos, which lists quotations from various forwarders, used in the analysis. Unloading times for general cargo ships and bulk carriers were calculated based on a rate of 50 tons/hour that was obtained from Japanese Shipowners' Association website. Trucking time was assumed to be one day.

Data used to calculate the container shipping company's profit and set parameters are shown in Table 6.2.

Table 6.2 Data for Calculation of Container Shipping Company Profits and Parameter Setting

	Data Source	**Notes**
Parameter		
Time Frame	Assumption	90 days
Volume Carried	Assumption	3,000 tons or 28,000 tons
Safety Coefficient	Assumption	1.65 (= 95% service rate)
S.D. of Demand	Assumption	100 tons
Interest Rate	Assumption	5%
Value Decaying Rate	Assumption	0.06% for grains, 0% for waste, 0.01% for other goods
Value Added for Goods	Assumption	10% (same as insurance company's assumption)
Parameter for Container Shipping Company		
Container Repairing Cost	Based on interviews with shipping company reps	1,000 USD/container
Probability of disorder	Based on interviews with shipping company reps	0.20%
Probability of undeliverable	Based on interviews with shipping company reps	0.001%
Container Retention Cost	Based on interviews with container leasing company reps	40.5 USD/month/container
Probability of Retention	Based on interviews with shipping company reps	10%
Container Procurement Cost	WB's Doing Business database	**Proxy:** Trucking cost to carry an empty container from the van pool to the shipper's site

Parameter values are based on interviews with practitioners. The container repair cost is assumed to be 1,000 USD. This was determined based on advice provided by a shipping company representative. However, it should be noted that the repair cost was considerably higher for containers that were badly damaged. The probability of failure (pr_1) was set at 0.2% based on interviews with representatives of the shipping companies. The probability of cargo abandonment (pr_2) was set at 0.001%. However, according to the shipping company representatives, in a normal environment, cargo abandonment only occurs once a year at most, and thus the probability is quite low. A container leasing fee of 40.5 USD was used, which is equivalent to a one month lease by the leasing company assuming that the container is returned by the end of the month. Regarding container leasing, the leasing fees vary depending on whether the lease is short term or long term and whether the container is new, therefore an average value was used. The container retention probability (pr_3) was set at 10%.

Container procurement costs are taken from the WB's Doing Business database. The inland transportation costs in each country were used to calculate the container procurement cost, which is the cost of sending containers from the container yard or empty container depot to the shipper's site and the cost of transporting containers from the mainhaul consignee's site back to the port. It is assumed that shipping companies cannot pass these costs on to the customers entirely. Interviewees stated that shipping companies may arrange trucks to transport containers from the shipper's site to the port, but the cost was not passed on to the shippers enough.

Regarding inventory costs, a standard deviation in demand of 100 tons and a safety factor of 1.65 (i.e., a service rate of 95%) was assumed to provide a suitable safety margin.

6.5 Calculations

Table 6.3 shows the total costs per ton of container transport and bulk transport of each type of good to each destination port. The cost of container transportation to Shanghai is lower for all types of goods except waste plastics, while the cost of bulk transportation to Yangon is lower for all types of goods. This implies that consignees prefer to avoid the cost and leadtime involved in transshipment because cargo to Yangon is carried direct. For routes to Shanghai, the base container freight rates are already low enough. This suggests that container shipping companies prefer to transport containers to gateway ports where there are numerous types of export cargo available for backhaul.

Table 6.3 Total Cost/Ton by Goods and Destinations

Unit USD/ton	To Shanghai		To Yangon	
	Container Shipping	**Bulk Shipping**	**Container Shipping**	**Bulk Shipping**
Ferrous Scrap (HS 7204)	**986**	993	923	**845**
Waste Plastics (HS 3915)	403	**372**	451	**309**
Soybeans (HS 1201)	**525**	534	589	**519**
Oilseeds (HS 1204–1207)	**2,415**	2,493	2,159	**2,134**
Organic Chemicals (HS 29)	**1,519**	1,532	2,520	**2,467**
Inorganic Chemicals (HS 28)	**3,730**	3,789	3,070	**3,025**
Flatroll (HS 7208–7212)	**2,197**	2,231	2,189	**2,140**
Aluminum (HS 76)	**2,754**	2,796	4,401	**4,391**
Total	**1,834**	1,860	2,073	**2,013**

Table 6.4 shows the total costs per ton of the various cost items for container transport and bulk transport to each destination. Container transport costs are higher in terms of freight rate but lower in terms of insurance premiums, change in the value of goods, and inventory costs. The lower insurance cost reflects the shorter leadtime. Moreover, multiple shipments free consignees from having to maintain a large inventory, which contributes to further cost reductions.

Table 6.4 Total Cost/Ton Comparison of Cost Items by Destination

Unit USD/ton	To Shanghai		To Yangon	
	Container Shipping	**Bulk Shipping**	**Container Shipping**	**Bulk Shipping**
Purchase Cost	1,623	1,623	1,810	1,810
Ocean Freight	47.7	**24.2**	124.7	**26.5**
Unloading/Inland Costs	**12.8**	14.4	**9.6**	10.2
Insurance	**21.5**	44.2	**24.8**	49.3
Tariffs	**97.0**	**97.1**	67.7	**65.4**
Procedural Costs	1.7	**0.2**	**1.7**	**0.2**
Cost of Change in the Value of Goods	**24.6**	43.0	**30.5**	44.4
Inventory Costs	**6.2**	13.8	**3.8**	7.6
Total	**1,834**	**1,860**	**2,073**	**2,013**

Table 6.5 shows the total costs per ton of container transport, bulk transport, and bulk transport to silos of 28,000 tons of soybeans on the Los Angeles–Shanghai route. The volume of cargo enabled by bulk shipping facilitates greater reductions in transportation costs than the corresponding increases in costs in relation to changes in the value of the goods and inventory costs. Moreover, the use of silos offers considerable benefits for bulk shipping in terms of economies of scale and reduced tracking and inventory costs.

Table 6.5 Total Cost/Ton Comparison for the Los Angeles–Shanghai Route (soybeans)

Unit USD/ton	**Container Shipping**	**Bulk Shipping**	**Bulk Shipping to Silos**
Purchase Cost	386	386	386
Ocean Freight	25	12	12
Unloading/Inland Costs	16	13	5
Insurance	9.6	9.6	9.6
Tariffs	12.2	12.2	12.2
Procedural Costs	0.18	0.02	0.02
Cost of Change in the Value of Goods	9	28	28
Inventory Cost	1.3	9	2.6
Total	456	471	457

Table 6.6 shows the average and median containerization rates of various goods from the exporting countries (the United States, EU countries, Brazil, and Japan) adopted in the analysis to China and five countries in Southeast Asia in 2017. Both the average value and the median value are shown because there are cases where the containerization rate is either very high or very low. Since IHS Markit's World Trade Analysis data are used for Table 6.6, the figures were calculated on a country-to-country basis[44]. Conversely, transportation costs are calculated on a port-to-port basis in the analysis undertaken in this chapter. It should be noted that goods are not in line with the HS codes because the data source is not aligned with this system. Because of these limitations, it is difficult to compare the data in Table 6.6 with

[44] In Table 6.6, figures on routes from EU countries are calculated on a region-to-country basis, while those for routes from Los Angeles and Houston are calculated on an area-to-country basis.

the results of these calculations, but they indicate that there is little difference between the results of the cost analysis and the real-world trend in containerized transportation.

Table 6.6 Comparison of Average and Median Containerization Rates by Goods and Destinations in 2017

	To China		To Myanmar, Cambodia, Brunei, Laos, and Papua New Guinea	
	Average	Median	Average	Median
Scrap Metal	50.4%	34.5%	41.5%	12.7%
Waste and Scrap of Rubber, Synthetic Fibers and Plastics	79.6%	83.4%	87.1%	89.7%
Soybeans	39.8%	2.2%	52.3%	52.3%
Oil Seeds and Oleaginous Fruits	57.3%	44.6%	100.0%	100.0%
Organic Chemicals	32.1%	24.3%	45.5%	18.0%
Inorganic Chemical Compounds	39.3%	32.1%	42.8%	18.9%
Flat-Rolled Iron and Steel Products	33.9%	23.1%	39.4%	11.8%
Aluminum	62.6%	68.9%	76.7%	68.2%

Source: IHS Markit’s World Trade Service

Regarding the Chinese market, the total cost tended to be lower for container transportation, but the containerization rate is not necessarily higher. One reason for this is that bulk transportation to China has progressed for goods such as soybeans, and thus facilities such as grain elevators are readily available. In other words, because the volume of goods transported to China is already massive, it is likely that the average bulk shipment is already larger than that expected by Table 6.3, and thus the cost advantages offered by containerized transport are lost.

Although it is not evident in Table 6.6, there is a tendency for lower containerization rates in relation to transportation from Brazil because the cost of container shipping to China is lower in all cases except for waste plastics and organic chemicals. The FE–South America route connecting Brazil and China is also known to be a highly imbalanced route, suggesting that there is an opportunity for BCC to help alleviate the trade imbalance between Brazil and China.

Container transportation seems to be reasonably popular despite the relatively high cost of container transportation to the five countries in Southeast Asia shown in Table 6.6. This is likely the result of the small volumes of cargo transported: the total volume of cargo shipped to these countries was only 107,200 tons in 2017. For destinations with low levels of demand, it is necessary to use container transportation, even though the cost is higher than that for bulk transport, and thus there is an opportunity to promote container transportation while demand remains low.

6.6 Sensitivity Analysis

Figures 6.5 to 6.8 show the results of comparisons of the total costs of container shipping and bulk shipping in terms of the frequency of container shipments, the purchase price of goods, the freight rate (base rate), and the period over which the cargo is consumed. These were the most important factors in relation to transport mode decision-making.

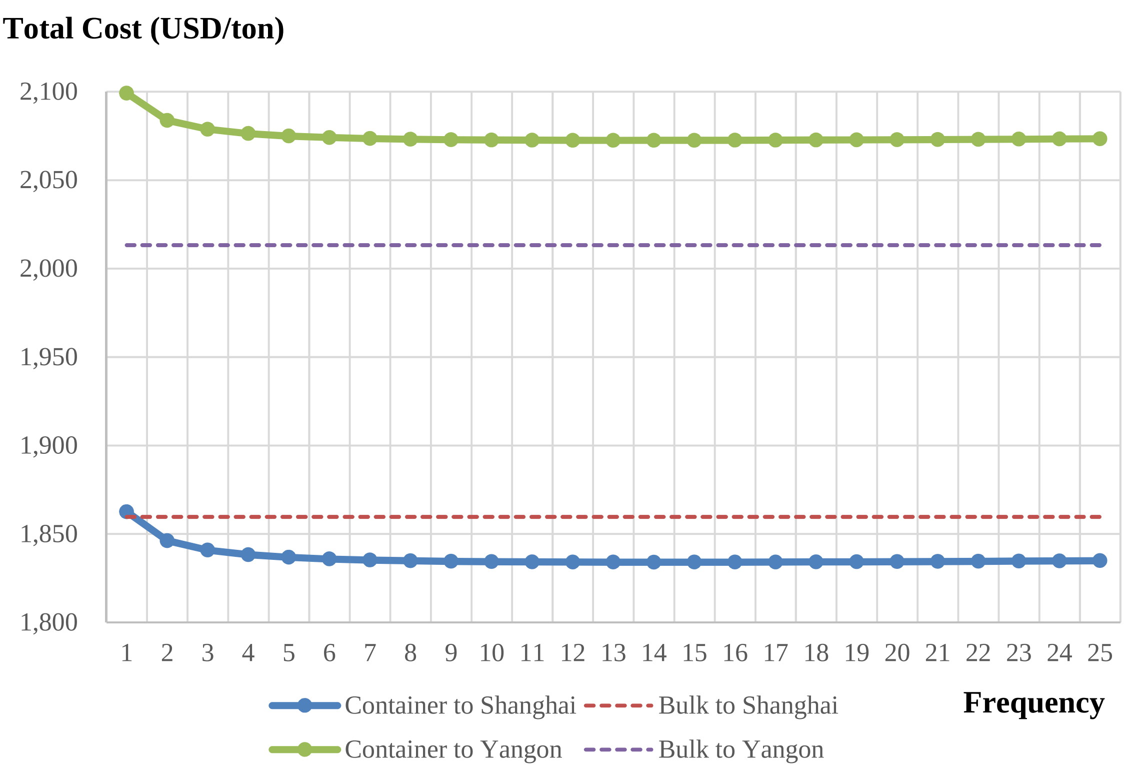

Figure 6.5 Sensitivity Analysis of Frequency of Shipping

Changes in the total cost of container shipping based on frequency are shown in Figure 6.5. The costs shown in Figure 6.5 are the average of all routes to Shanghai and Yangon. The total costs of bulk shipping, which remain constant, are also shown in Figure 6.5. The results of the sensitivity analysis in relation to container shipping frequency suggest that the total costs of container shipping are higher for routes to Shanghai if there is only one shipment. However, there is a significant reduction in total costs as the number of shipments increases from one to two, and total cost become lower than bulk shipping. This is because multiple shipments lead to reductions in inventory costs and costs related to changes in the value of the goods. Since the purchase price of goods accounts for the greatest proportion of the total cost of shipping, the impact of such a change is significant. There is also a significant reduction in total costs of container shipping is occurred for routes to Yangon, but total cost for container shipping remained higher than bulk shipping.

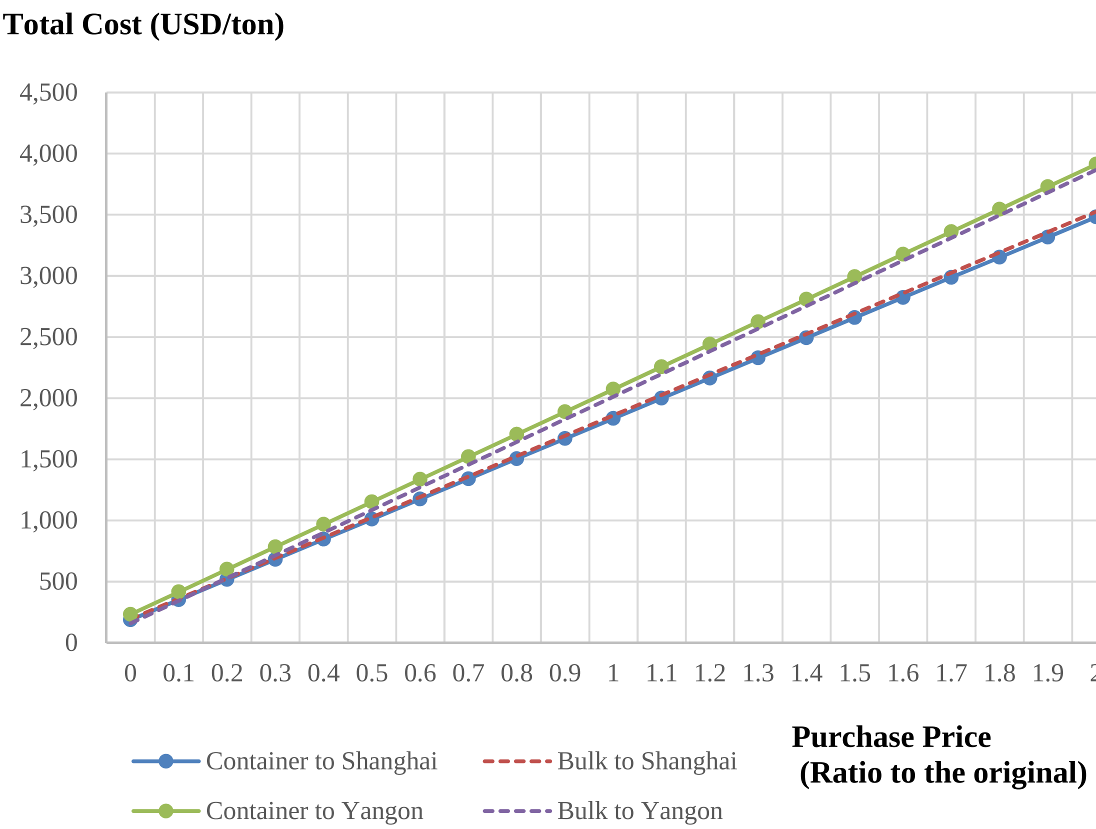

Figure 6.6 Sensitivity Analysis of Changes in the Purchase Price

Figure 6.6 shows changes in the total cost of container shipping in relation to changes in the purchase price of the goods shipped. As the purchase price increases, there is a tendency for the cost of container transportation to fall. Although it is not evident in the range presented in Figure 6.6, if the purchase price rises to about five times the current level, the cost of container transportation to Myanmar will also be lower than bulk trasnportation.

Container freight rates are the most influential factor in relation to total costs. Figure 6.7 shows the changes in the total cost of container shipping in relation to changes in the base rate. The base rate is the main component of container freight rates, which consist of the base rate and surcharges such as THCs. On the Myanmar route, if the base rate falls to about half the original level, the cost of container transportation will be lower than that of bulk transportation. Conversely, on routes to China, if the base rate increases to about one and a half times the original level, the cost competitiveness of container shipping is lost.

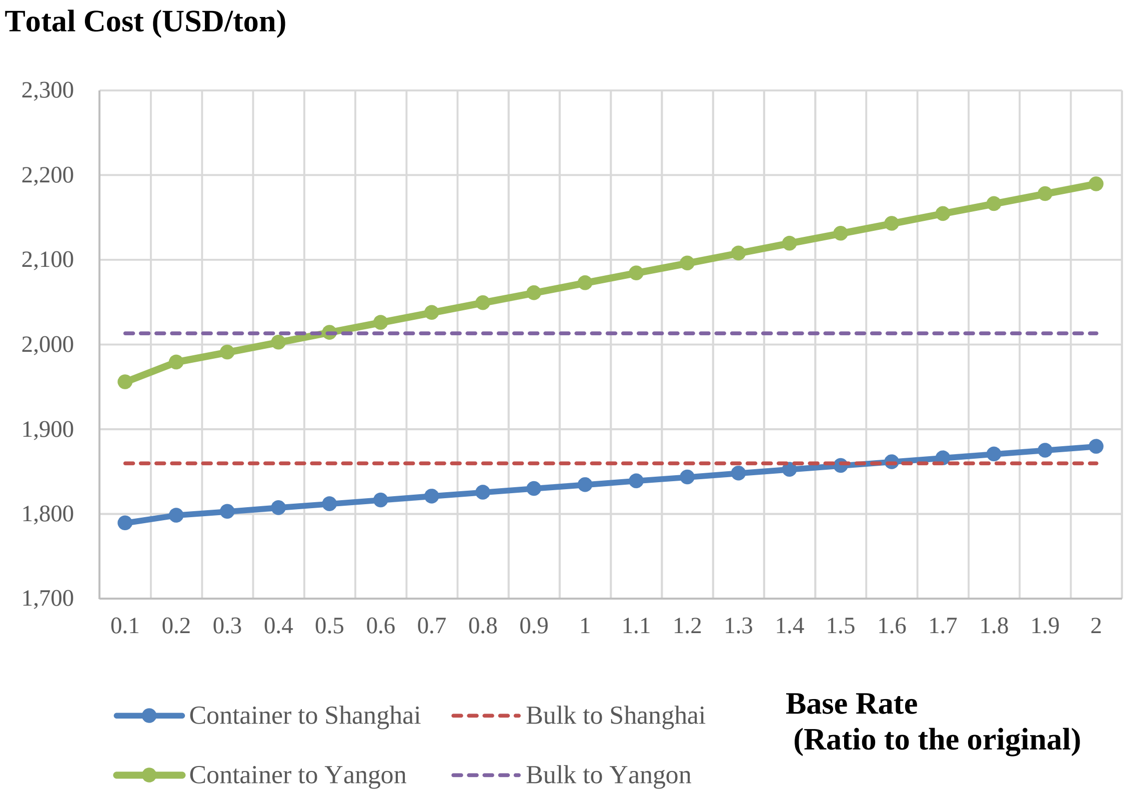

Figure 6.7 Sensitivity Analysis of Changes in the Base Rate

The period until the cargo is consumed is another significant factor in total costs. Figure 6.8 shows the changes in the total cost of bulk shipping in relation to the period over which the cargo is consumed. It can be seen that Figure 6.8 differs from Figures 6.5, 6.6, and 6.7 in that the total cost of bulk shipping changes as the period over which the cargo is consumed changes, while that of container shipping remains unchanged. A longer period suggests the demand for the cargo becomes weaker. Inventory costs and costs from changes in the value of the goods will be higher for bulk shipping because the consignee has to store this cargo for longer. Thus, container shipping, which enables smaller shipments, is preferable because it lowers inventory costs and costs from changes in the value of the goods. Even for the route to Myanmar, container shipping is cost-competitive in relation to bulk shipping if the period of consumption for bulk goods is four times longer than the base period of 90 days.

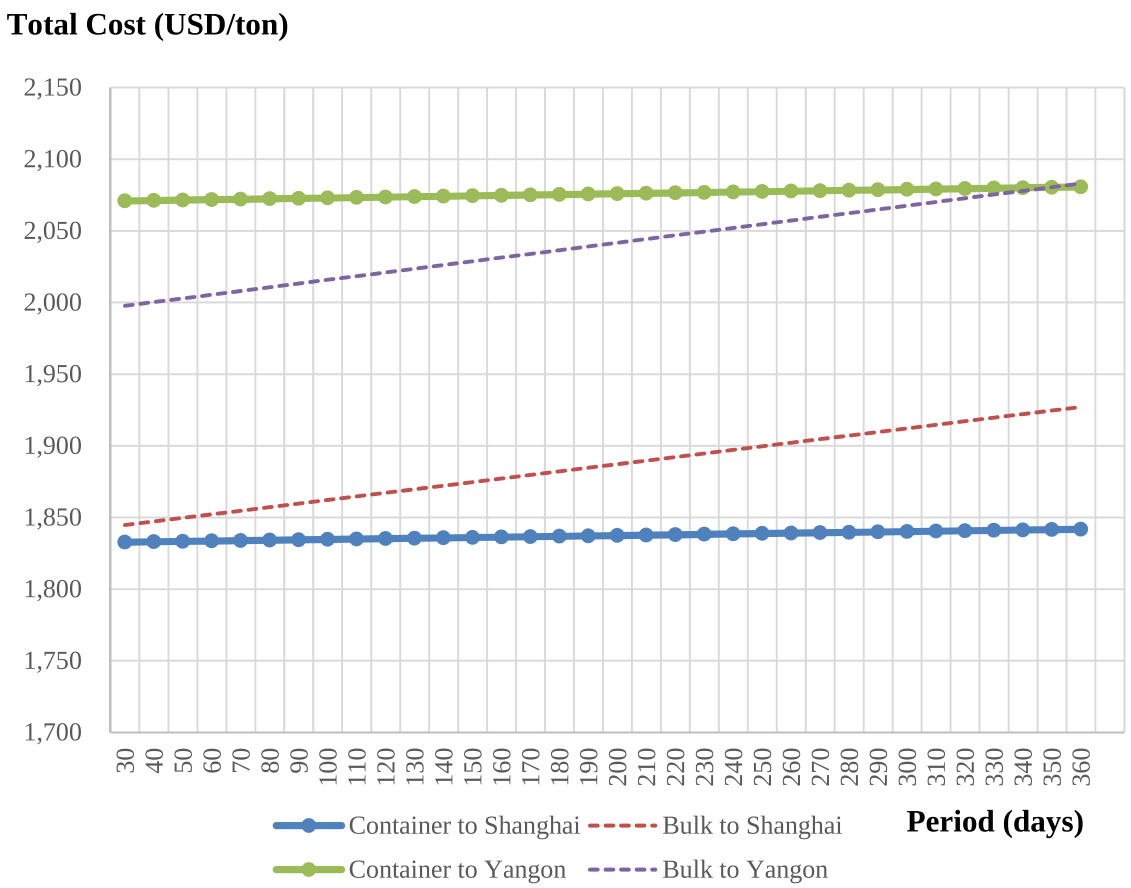

Figure 6.8 Sensitivity Analysis for Changes in the Period until Cargo is Consumed

6.7 Incentives for Container Shipping Companies

Table 6.7 shows container freight rates, container procurement costs, THCs, and the difference in profit expressed as $\pi_1 - \pi_2$. π_1 is the total profit from the round trip, while π_2 is the profit from not engaging in BCC. The figures in the right-hand column of Table 6.7 represent $\pi_1 - \pi_2$ per container, and indicate whether a container shipping company has sufficient incentive to offer transport using containers for various routes. It is assumed that the container freight rate and transport volume per shipment are both constant.

Table 6.7 Container Freight Rates, Procurement Costs, THCs, and Differences in Profit for Each Route

Unit USD/container	Container Freight Rate	Container Procurement Cost	THC	$\pi_1 - \pi_2$
Houston to Shanghai	1,372	1,361	727	629
Houston to Yangon	2,327	1,361	815	709
Los Angeles to Shanghai	576	1,361	777	–115
Los Angeles to Yangon	1,873	1,361	865	–148
Santos to Shanghai	1,232	763	399	759
Santos to Yangon	2,475	763	487	1,275
Rotterdam to Shanghai	1,357	315	513	1,447
Rotterdam to Yangon	2,331	315	601	1,505
Yokohama to Shanghai	467	323	547	585
Yokohama to Yangon	2,007	323	635	928

Profits are reduced on the Los Angeles–Shanghai route when container shipping is used because of high container procurement costs and low container freight rates. Since the Los Angeles–Shanghai route is one of the busiest shipping routes in the world, numerous shipping companies are entering the market, and thus the fares for container shipping have become extremely competitive, which is expected. Meanwhile, damage to containers, cargo abandonment, and retention of containers at the destination port do not seem to present problems. Incentives for container shipping companies seem to be greater in relation to the routes to Yangon, but shipping is usually outsourced to operators on feeder routes, and thus it seems that the incentives for large shipping companies are less than the figures in Table 6.7 would suggest.

6.8 Chapter Conclusion

In conclusion, the findings in relation to the hypotheses proposed in Section 6.1 are presented. Hypothesis 1 proposed that a reduction in costs such as fares promoted containerization. This is valid for freight rates, although a substantial reduction in fares is required. As for costs other than freight costs, the ratio of these costs to the total cost is so low that it is difficult to promoted BCC by reducing these costs, indeed container shipping is already cheaper in terms of inventory costs. Thus, Hypothesis 1 is not supported. This also implies that digitization and innovations in container shipping will not provide sufficient cost reductions to promote the adoption of BCC, and thus Hypothesis 1a is not supported either.

Hypothesis 2, which proposed that container transportation will not be competitive against bulk transportation using facilities such as silos and elevators, is supported. Despite bulk transport leading to increased inventory costs, all other conditions being equal, the effect of economies of scale through the use of bulk cargo facilities on reducing cargo handling costs and inventory costs is significant. Finally Hypothesis 3 which proposed that container shipping companies have an incentive to use BCC to alleviate trade imbalances, was somewhat supported, although the incentive is not significant.

CHAPTER 7

CONCLUSION

7.1 Summary

In this dissertation, several reviews and analyses and a survey have been conducted to fulfill three objectives relating to issues regarding BCC. In Chapter 2, the history of containerization, challenges to containerization, and the current status of BCC were reviewed. In Chapter 3, the existing literature was reviewed. In Chapter 4, an econometric analysis was conducted. The results indicated that to encourage containerized shipping of goods that currently have low containerization rates, it is essential to reduce export and import procedure costs including freight costs to the port, costs after landing, and costs in relation to customs procedures, as well as undertaking maintenance of port and land infrastructure. In Chapter 5, the decision-making mechanism was examined based on interviews with practitioners, and it was found that the consignee is the leading decision-maker. Most respondents emphasized that the choice of transport mode must obey economic principles, and thus it was found that a reduction in freight rates is the most important factor influencing decision-making. In addition, reductions in other costs such as unloading costs and procedural costs are essential in promoting BCC. In Chapter 6, a cost analysis was conducted to test the hypotheses that were presented. The results suggested that a reduction in freight rates would be effective, while reductions in other costs do not seem to be sufficient to promote BCC. The results also suggested that BCC is more suitable when demand is weakening. Further, container shipping companies have incentives to promote BCC for some goods and routes, but these incentives are not strong. A summary of these results is presented below, followed by concluding remarks.

7.2 Clarification of the Mechanism Underlying BCC

Here, research objectives 1 to 3 are addressed. In relation to objective 1, an econometric analysis provided several findings from the macroeconomic viewpoint. It was found that goods with a low containerization rate are mainly carried on backhaul journeys, and BCC may be useful in reducing imbalances. The analysis suggests that investment in infrastructure and a reduction in export and import costs should promote the containerization of goods that currently have a low containerization rate.

Regarding objective 2, an examination of the decision-making process revealed that factors such as ocean freight costs, loading/unloading costs, and customs clearance costs had the greatest effect on the choice of transport mode. However, the cost analysis presented in Chapter 6 suggested that reductions in these costs would not be sufficient to promote BCC.

In relation to objective 3, the cost analysis revealed that a reduction in the freight rate is the most effective means of promoting BCC, but a considerable reduction is necessary. Other costs such as procedural costs are not significant factors. Expanded analyses are expected to provide more insights regarding the promotion of BCC.

In this dissertation, the mechanism underlying BCC was examined based on the current situation from both the macroeconomic and microeconomic points of view. In Chapter 2, the current status of containerization and problems confronting containerization were reviewed, and the goods and routes that should be considered for BCC were identified. It was found that BCC is useful in backhaul trade from developed countries to developing countries and trade between developing countries such as from Brazil to China, and that the most appropriate goods include food, building materials, raw materials, and recycling materials. Furthermore, BCC is useful for carrying small volumes of differentiated goods.

In Chapter 4, the relationship between the macroeconomic environment including infrastructure and aggregated containerization was examined using econometric analysis. It was found that BCC could provide a solution to the problem of imbalance in containerized transportation. Further, it was found that infrastructure development, as well as institutional improvements, particularly in importing countries, could contribute to the development of BCC.

Chapter 5 examined the decision-making structure and factors influencing BCC based on interviews with practitioners. In promoting BCC, consignees play a leading role in decision-making, while freight rates, costs other than freight such as inventory costs, and other factors such as item characteristics and leadtime play a substantial role in decision-making. Consignees play a leading role because they have to manage the supply chain and develop import systems. Thus, they play a leading role in decision-making in relation to BCC because of the nature of the goods handled by BCC. It seems that goods transported by BCC tend to require some degree of processing, either by the consignee or by other parties, although further verification is necessary in relation to this issue.

Chapter 6 presented an analysis of decision-making in relation to BCC based on the total cost of transport including purchase costs for consignees and marginal profits for container shipping companies. For consignees, reduced freight rates and demand are the most significant factors influencing the choice of containerized transportation, while reductions in customs clearance costs do not have a significant effect.

What is important here is that while practitioners are aware that costs are important, macroeconomic environmental factors are implicitly also recognized as influencing decision-making, that is, they involve costs that cannot be directly converted into monetary terms. This is why both microeconomic cost factors and macroeconomic environmental factors are included in Figure 5.2. Conversely, these implicit costs do not account for a substantial share of total costs for individual consignees. Thus, these costs are not emphasized in Chapter 6. However, at the national level, it seems that greater benefits can be realized by developing not only hard infrastructure such as ports and roads, but also soft infrastructure such as improved customs clearance procedures.

7.3 Practical Applicability

The results presented in the previous chapters are useful for practitioners. First, they can assist container shipping companies in utilizing BCC as a strategy to help eliminate imbalances. This in turn can help to improve these companies' operational efficiency.

In addition, it became clear who will have the most influence in promoting BCC. The results of interviews with practitioners presented in Chapter 5 showed that the consignee's role is essential because they control the acceptance system for imported cargo and consider the supply chain when deciding whether to use containerized import for bulk cargo. Even if trade conditions such as CIF are used, it is difficult to ignore consignee requests. Thus, it is crucial to encourage consignees, who play a leading role, by understanding their needs, thereby potentially creating new business.

Furthermore, in clarifying what kinds of goods to select and what measures to take in promoting BCC, it is necessary to provide suggestions not only to container shipping companies but also to port authorities. It was shown that it is essential to select goods with a relatively low level of demand and to promote the selection of BCC by reducing freight rates. This finding is useful because it provides guidelines for container shipping companies, governments, and port authorities to promote BCC.

The information presented in Chapter 2 suggests that BCC would be beneficial on imbalanced routes from developed countries to developing countries. It is crucial to attract goods that currently do not have a high containerization rate such as raw materials, food ingredients, building materials, and recycling products. In addition to the transportation of differentiated items, the benefits of BCC are expected to be demonstrated in transportation to areas where demand is either expected to increase in the future or has already decreased. This is confirmed by the results presented in Chapter 4.

Regarding the relationship between BCC and factors such as a reduction in procedural costs and increased investment in ports, the results presented in Chapter 4 suggest that these efforts can be useful to some extent in promoting BCC. However, the results presented in Chapter 6 suggest that the effects of these efforts are limited, and thus it is necessary to combine these approaches with other initiatives to promote BCC.

Based on the results presented in the previous chapters, the following actions are recommended to promote BCC. First, shipping companies should consider outsourcing cargo collection and marketing activities because shippers and consignees of BCC tend to be small. This presents a burden for container shipping companies, but forwarders specialize in these types of activities. Thus, container shipping companies will be freed of this burden by outsourcing. This will also strengthen the role played by logistics-related subsidiaries of shipping companies such as Damco and Yusen Logistics.

In addition, innovations in terms of digitization are necessary to collect as much information as possible about customers. Goods transported by BCC tend to be aimed at meeting temporary demand, and thus identifying customer characteristics is essential for promoting BCC. For example, collecting information about shippers and consignees using blockchain technology is useful prior to entering into transactions because shipping companies can verify the credit status of shippers and consignees. This reduces the risk of nonpayment, container retention, or cargo abandonment.

Second, for port authorities and government officials, the results presented in Chapter 6 suggest that transshipment may interfere with BCC. Thus, it is recommended that port authorities develop infrastructure to enhance convenience because BCC is preferable for direct transport routes. Further, enhanced port facilities provide increased incentives for shipping companies. Further, even though the results presented in Chapter 6 did not support the hypothesis that a reduction in procedural costs is essential for promoting BCC, such a reduction should still be pursued to facilitate increased trade. Even though cost reductions alone are insufficient to promote BCC, they will affect not only BCC but also the future of other forms of container shipping.

In addition, the provision of subsidies might be a useful strategy for promoting BCC, particularly in importing countries such as the US. It is recommended that subsidies should be provided to encourage backhaul cargo to reduce shippers'/consignees' burdens, especially in relation to PSW ports, because the most effective way to promote BCC is a significant reduction in freight rates. It is also recommended that these subsidies should be distributed not only to shippers/consignees but also to container shipping companies that carry containerized bulk cargo. Subsidies to container shipping companies to encourage the use of BCC seem preferable to the construction of transloading facilities, as is currently being promoted by port authorities in California.

7.4 Limitations and Future Research

Although this study revealed several useful findings, the analyses were limited by data constraints and the methodologies used. For example, there was no consideration of seasonal and short-term fluctuations in demand and supply because the containerization rate was only considered on an annual basis. There is a possibility that the containerization rate falls at various times of the year, in particular at grain harvest time, which might lead to either under- or overestimation of containerization rates. The limited route information for the cluster analysis undertaken in Chapter 4 meant that no evidence was available regarding risk hedging by route. Future research is necessary in relation to this issue using improved methodologies and more detailed data. It might also be necessary to pressure governments and the UNCTAD to release trade statistics by transportation mode, including container trade[45].

Finally, this dissertation was unable to discuss the relationship between containerization and the demand or product cycle in sufficient depth. As Miyashita (2002) and Murakami and Matsuse (2014) noted in their analyses of the product cycle and choices in transportation mode between maritime container transport and air cargo, the relationship between containerization and the product cycle seems to be important, as noted in Chapter 2. Further analysis of this relationship should be undertaken in future studies.

[45] To the best of the author's knowledge, the US and Japan are the only sources of information regarding containerized trade. The EU releases trade statistics by transportation mode, but they only show the seaborne trade volumes.

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APPENDIX I

PER CAPITA GDP OF DEVELOPED COUNTRIES AND DEVELOPING COUNTRIES

Table A.I.1 Nominal *per capita* GDP of Developed Countries and Developing Countries Classified by IMF

Developed Economies		Developing Economies							
Country	2017	Country	2017	Country	2017	Country	2017	Country	2017
Luxembourg	105,803	Qatar	60,804	Dominica	7,921	Indonesia	3,876	Cambodia	1,390
Switzerland	80,591	United Arab Emirates	37,226	Botswana	7,877	Armenia	3,861	Mauritania	1,318
Macao	77,451	The Bahamas	31,255	Montenegro	7,647	Mongolia	3,640	Myanmar	1,264
Norway	74,941	Brunei Darussalam	29,712	Dominican Republic	7,375	Tuvalu	3,638	Zimbabwe	1,176
Ireland	70,638	Kuwait	27,319	St. Vincent and the Grenadines	7,271	Marshall Islands	3,625	Kyrgyz Republic	1,144
Iceland	70,332	Bahrain	24,029	Peru	6,762	Tunisia	3,496	Senegal	1,038
United States	59,501	Saudi Arabia	21,120	Venezuela	6,684	Bolivia	3,353	Tanzania	1,034
Singapore	57,713	Oman	17,973	Turkmenistan	6,643	Cabo Verde	3,238	Eritrea	980
Denmark	56,444	Barbados	17,859	Thailand	6,591	Micronesia	3,200	Ethiopia	873
Australia	55,707	Palau	17,096	Colombia	6,273	Morocco	3,151	Nepal	834
Sweden	53,218	Uruguay	16,722	South Africa	6,180	Vanuatu	3,094	Benin	830
Netherlands	48,346	Antigua and Barbuda	16,702	Ecuador	6,098	Philippines	2,976	Tajikistan	824
San Marino	47,406	St. Kitts and Nevis	16,296	Serbia	5,899	Bhutan	2,903	Mali	811
Austria	47,290	Trinidad and Tobago	15,769	Belarus	5,760	Papua New Guinea	2,861	Chad	810
Hong Kong	46,109	Seychelles	15,686	Suriname	5,746	Honduras	2,766	Guinea-Bissau	794
Finland	46,017	Hungary	15,531	Fiji	5,740	Ukraine	2,583	Comoros	788
Canada	45,077	Panama	15,089	Jordan	5,678	Lao P.D.R.	2,542	Haiti	784
Germany	44,550	Chile	15,070	FYR Macedonia	5,474	Egypt	2,501	Rwanda	772
Belgium	43,582	Argentina	14,467	Namibia	5,413	Vietnam	2,354	Guinea	749
New Zealand	41,593	Poland	13,823	Islamic Republic of Iran	5,305	Moldova	2,280	Liberia	729
Israel	40,258	Croatia	13,138	Bosnia and Herzegovina	5,149	Nicaragua	2,207	Uganda	699
France	39,869	Equatorial Guinea	12,727	Iraq	5,088	Timor-Leste	2,104	Burkina Faso	664
United Kingdom	39,735	Maldives	12,527	Jamaica	5,048	Solomon Islands	2,081	Togo	611
Japan	38,440	Costa Rica	11,685	Libya	4,859	Nigeria	1,994	Afghanistan	588
Italy	31,984	Lebanon	11,409	Belize	4,806	Djibouti	1,989	Yemen	551
Puerto Rico	30,488	Romania	10,757	Guyana	4,710	India	1,983	Sierra Leone	491
Korea	29,891	Russia	10,608	Albania	4,583	Republic of Congo	1,958	The Gambia	480
Spain	28,359	Turkey	10,512	Guatemala	4,472	São Tomé and Príncipe	1,785	Democratic Republic of the Congo	478
Malta	27,250	Grenada	10,360	Angola	4,408	Kiribati	1,721	Madagascar	448
Cyprus	24,976	Brazil	9,895	El Salvador	4,400	Kenya	1,702	Niger	440
Taiwan	24,577	Malaysia	9,813	Algeria	4,292	Ghana	1,663	Mozambique	429
Slovenia	23,654	Mauritius	9,794	Paraguay	4,260	Côte d'Ivoire	1,617	Central African Republic	387
Portugal	21,161	St. Lucia	9,607	Samoa	4,253	Bangladesh	1,602	Malawi	324
Czech Republic	20,152	Mexico	9,304	Tonga	4,177	Pakistan	1,541	Burundi	312
Estonia	19,840	Kazakhstan	8,841	Azerbaijan	4,141	Uzbekistan	1,491	South Sudan	228
Greece	18,637	China	8,643	Georgia	4,099	Zambia	1,480	Somalia	n/a
Slovak Republic	17,664	Nauru	8,575	Sri Lanka	4,085	Sudan	1,428	Syria	n/a
Lithuania	16,730	Bulgaria	8,064	Swaziland	3,915	Lesotho	1,425		
Latvia	15,547	Gabon	7,972	Kosovo	3,880	Cameroon	1,401		

Source: the IMF's World Economic Outlook database

APPENDIX II

DETAILED CLUSTER ANALYSIS RESULTS

Table A.II.1 Detailed Classification of Goods Included in the Cluster Analysis

Cluster No.	Number of Goods	Goods
1 (Middle)	8	Building Stone, Worked and Non-Metallic Mineral Products, n.e.s., Cement and Lime, Fertilizers and Pesticides, Metal Structures, Reservoirs and Tanks, Non-Refractory Clay and Ceramic Products, Veneer, Plywood, Particle Board, Waste and Scrap Rubber, Synthetic Fibers and Plastics, Waste Paper, n.e.s.
2 (Middle)	5	Chemical Products, n.e.s., Fruits and Vegetables, Prepared or Preserved, Inorganic Chemical Compounds, Plastics in Primary Forms and Synthetic Rubber, Wood of Non-Coniferous Species
3 (High)	44	Agricultural Machinery, n.e.s., Aircraft and Parts, Apricots and Peaches, Fresh, Beef, Fresh or Chilled, Chicken and Turkey Meat, Pork, Fresh or Chilled, Cutlery, Non-Electric Cooking Appliances, Scissors and Blades, Essential Oils, Perfumes and Beauty Preparations, Fruit, Dried, Tobacco, Unmanufactured, Copper Plates, Sheets, Foil, Powders, Tubes and Pipes, Corn and Soybean Oil, Footwear, n.e.s., Footwear Parts, Industrial Ovens, Furnaces and Furnace Burners, Lemons, Grapefruit, and other Citrus Fruits, Metal Working Machinery, n.e.s. and Parts, Milk Not Concentrated, Yogurt and Ice Cream, Musical Instruments and Parts, Soybeans, Sunflower, Sesamum, Colza and Mustard Seeds, Transport Equipment and Parts, n.e.s., Live Animals
4 (High)	3	Cotton, Synthetic Fibers, Textile Fabrics, Woven, excl. Narrow or Special Fabrics
5 (High)	20	Aluminum, Articles of Concrete, Cement and Plaster, Basic Iron and Steel, Chemical Elements, General Industrial Machinery, n.e.s., Insulated Wire and Cable, Accumulators and Batteries, Kiwi Fruit, Guavas, Mangos and Durians, Fresh, Metal Products, Non-Alcoholic Beverages, Beer and Cider, Plastic Tubes, Pipes, Plates and Film, Plastics in Non-Primary Forms and Plastic Products, n.e.s., Sugar, Beet or Cane, Pulp, Rubber Products, Printing and Writing Paper, Molasses and Other Sugars
6 (High)	25	Apples, Pears and Plums, Fresh, Bearings and Gears, Boilers, Engines and Turbines, excl. Aircraft and Vehicle Engines, Cauliflower, Broccoli, Cabbages and Lettuce, Fresh or Chilled, Dental Hygiene, Hair, and Shaving Preparations, Electric Engines, Generators and Transformers, Electrical Equipment, n.e.s., Vegetables, n.e.s., Fresh or Chilled, Plastic Builders' Ware, Floor Coverings, Meat, Prepared or Preserved, Heating and Cooling Equipment, n.e.s., Oranges and Mandarins, Paints, Varnishes and Lacquers, Wood Products, n.e.s., Textile Yarn, Special Industrial Machinery, n.e.s.
7 (Low)	10	Agriculture and Food Processing Residue and Waste, n.e.s., Animal and Vegetable Oils, n.e.s., Bananas, Hay, Fodder, Bran, Oilcake, Machinery and Equipment for Mining and Construction, n.e.s., Meat and Fish Products, Not for Human Consumption, Dog and Cat Food, Motor Vehicles, Natural Rubber, Gums and Resins, Rice, Wood and Cork Waste, Sawdust, Charcoal
8 (Low)	5	Flat-Rolled Products of Iron and Steel, Iron and Steel, n.e.s., Organic Chemicals, Sands, Pebbles, Gravel and Crushed Stone, Stone, Clay and Other Crude Minerals
9 (Middle)	3	Crude Fertilizers, Newsprint and Uncoated Paper and Paperboard, excl. Printing Paper, Oil Seeds and Oleaginous Fruits, n.e.s.
10 (Low)	4	Mineral Tars and Distillation Products, Petroleum Jelly, Palm, Coconut and Palm Kernel Oil, Pitch Coke, Petroleum Coke, Bitumen, Scrap Metal

APPENDIX III

CONTAINERIZATION RATES FOR VARIOUS ROUTES BY CLUSTER

Table A.III.1 Containerization Rates by Route for Cluster 1

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			51.2%	73.0%	50.3%	59.7%	62.0%	77.6%	59.0%	60.9%	
Hong Kong			70.4%	51.9%	31.3%	58.1%	66.9%	63.4%	73.3%	56.5%	70.6%
Indonesia	64.6%	58.5%		66.2%		30.9%	57.4%	72.3%	66.8%	37.6%	43.1%
Japan	45.4%	47.1%	46.3%		30.2%	27.1%	21.4%	52.0%	59.2%	57.7%	37.8%
Malaysia	56.1%	70.7%		56.7%		41.9%		64.0%	68.6%		53.8%
Philippines	53.2%	60.7%	53.3%	69.7%	54.4%		54.1%	60.1%	70.4%	47.2%	22.3%
Singapore	48.1%	75.6%	55.7%	66.7%		38.7%		58.8%	70.8%	56.9%	53.9%
South Korea	65.2%	72.5%	28.3%	23.1%	28.7%	28.8%	44.5%		57.6%	23.2%	34.5%
Taiwan	67.3%	42.7%	52.0%	44.1%	27.6%	42.2%	32.0%	30.2%		48.4%	31.0%
Thailand	48.0%	75.3%	44.9%	60.4%		63.1%	52.9%	67.3%	67.4%		45.4%
Vietnam		50.7%	30.9%	78.1%	24.4%	48.4%	51.8%	56.3%	48.7%	62.5%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.2 Containerization Rates by Route for Cluster 2

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			42.8%	50.3%	61.4%	47.4%	51.4%	51.9%	43.0%	40.2%	
Hong Kong			76.3%	74.4%	67.2%	67.6%	63.0%	79.0%	79.5%	70.9%	81.5%
Indonesia	42.9%	66.7%		51.3%		55.3%	54.2%	40.5%	41.5%	49.8%	55.9%
Japan	70.7%	91.7%	70.4%		67.3%	34.9%	62.3%	64.4%	60.2%	76.5%	79.2%
Malaysia	55.5%	87.6%		53.3%		66.2%		50.7%	49.1%		72.5%
Philippines	49.2%	60.8%	48.3%	43.5%	59.0%		53.1%	52.7%	50.7%	61.0%	84.0%
Singapore	66.6%	96.1%	82.9%	73.3%		83.6%		69.8%	82.8%	70.4%	87.1%
South Korea	78.4%	97.5%	63.9%	74.4%	74.6%	63.1%	78.1%		74.3%	48.2%	69.3%
Taiwan	89.7%	93.6%	71.1%	82.8%	79.0%	60.2%	65.8%	66.1%		78.3%	87.5%
Thailand	47.8%	90.4%	67.6%	61.3%		69.9%	60.3%	55.8%	55.1%		79.1%
Vietnam		54.0%	61.6%	52.9%	56.3%	54.1%	51.6%	50.3%	50.8%	65.7%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.3 Containerization Rates by Route for Cluster 3

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			81.0%	89.2%	87.7%	89.2%	69.6%	82.9%	30.0%	77.0%	
Hong Kong			94.8%	81.7%	92.7%	93.9%	96.1%	94.3%	98.0%	95.5%	99.1%
Indonesia	29.5%	78.8%		81.7%		81.0%	69.1%	72.2%	42.2%	70.2%	69.8%
Japan	66.9%	86.8%	63.6%		68.9%	66.0%	80.6%	73.7%	69.5%	71.9%	69.6%
Malaysia	59.9%	72.6%		73.7%		39.9%		78.7%	75.3%		55.3%
Philippines	43.0%	69.6%	81.0%	77.6%	85.0%		91.3%	53.5%	62.7%	83.2%	82.4%
Singapore	72.2%	91.2%	78.9%	89.4%		69.8%		91.0%	87.1%	88.3%	88.5%
South Korea	73.5%	83.5%	84.2%	81.9%	73.9%	69.1%	62.4%		79.6%	78.6%	86.4%
Taiwan	76.7%	82.8%	83.1%	72.3%	78.1%	74.1%	74.9%	79.9%		72.1%	74.7%
Thailand	83.9%	85.5%	78.0%	86.5%		88.3%	69.0%	50.8%	77.3%		59.9%
Vietnam		90.9%	77.1%	84.0%	46.0%	76.7%	63.8%	34.8%	82.3%	85.6%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.4 Containerization Rates by Route for Cluster 4

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			87.9%	93.0%	100%	95.3%	97.4%	100%	85.3%	90.6%	
Hong Kong			95.9%	81.4%	97.5%	96.1%	99.9%	92.3%	84.7%	96.4%	98.9%
Indonesia	74.2%	91.3%		92.3%		91.5%	97.2%	87.9%	85.5%	86.0%	84.0%
Japan	82.5%	100%	81.3%		100%	100%	100%	100%	100%	100%	92.2%
Malaysia	70.2%	100%		89.2%		98.5%		81.6%	90.8%		85.3%
Philippines	94.7%	95.6%	95.0%	99.9%	90.0%		100%	94.7%	100%	91.1%	99.5%
Singapore	64.0%	100%	90.7%	84.8%		90.2%		81.8%	81.5%	85.4%	87.6%
South Korea	98.4%	97.7%	77.6%	90.4%	90.3%	93.2%	91.8%		90.1%	72.6%	79.8%
Taiwan	96.9%	96.2%	89.2%	84.0%	85.2%	93.5%	87.3%	82.0%		84.1%	85.0%
Thailand	65.7%	100%	82.1%	85.5%		84.0%	93.2%	82.7%	82.8%		83.8%
Vietnam		87.8%	86.2%	95.5%	98.3%	88.0%	95.1%	90.2%	84.8%	88.2%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.5 Containerization Rates by Route for Cluster 5

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			83.1%	87.0%	92.4%	93.5%	94.7%	80.2%	85.5%	86.2%	
Hong Kong			79.9%	90.6%	90.1%	92.9%	95.1%	92.8%	94.7%	82.0%	96.9%
Indonesia	37.4%	98.2%		81.1%		93.7%	92.5%	31.6%	63.1%	85.7%	78.7%
Japan	60.6%	94.5%	61.1%		79.1%	79.9%	91.5%	42.0%	34.2%	65.1%	44.6%
Malaysia	71.6%	88.8%		83.1%		79.5%		36.7%	88.2%		68.6%
Philippines	77.5%	92.7%	91.8%	87.5%	95.1%		93.2%	86.9%	83.2%	82.7%	90.5%
Singapore	90.1%	94.1%	88.4%	92.9%		96.0%		85.9%	83.9%	87.3%	93.9%
South Korea	87.9%	90.9%	61.5%	73.5%	86.1%	45.6%	90.3%		68.2%	64.7%	73.5%
Taiwan	88.6%	91.4%	61.6%	85.1%	84.0%	75.1%	90.6%	57.8%		72.9%	72.5%
Thailand	79.5%	85.6%	87.6%	92.7%		73.1%	86.7%	94.4%	88.9%		81.8%
Vietnam		89.9%	79.7%	85.6%	86.2%	69.6%	97.8%	78.0%	99.5%	64.8%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.6 Containerization Rates by Route for Cluster 6

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			87.8%	90.9%	93.2%	94.0%	91.9%	88.4%	91.7%	92.8%	
Hong Kong			93.6%	89.8%	89.2%	91.8%	90.3%	90.2%	91.9%	88.4%	95.8%
Indonesia	88.6%	96.2%		81.1%		96.1%	90.0%	97.1%	88.7%	92.5%	94.4%
Japan	90.3%	93.1%	88.6%		90.0%	75.0%	90.2%	80.4%	73.4%	91.4%	88.4%
Malaysia	76.9%	93.4%		82.8%		93.4%		91.9%	75.8%		95.0%
Philippines	76.8%	83.9%	92.1%	78.1%	91.8%		86.5%	82.1%	91.3%	92.8%	93.0%
Singapore	92.4%	93.0%	91.2%	93.3%		90.9%		95.6%	94.0%	90.0%	92.7%
South Korea	89.1%	95.5%	94.2%	88.3%	92.6%	90.2%	92.1%		90.9%	90.7%	93.5%
Taiwan	93.9%	95.8%	94.5%	84.7%	91.7%	90.6%	93.2%	94.3%		93.3%	95.4%
Thailand	93.4%	92.1%	95.0%	95.3%		94.8%	94.9%	97.2%	95.5%		94.8%
Vietnam		85.3%	88.8%	86.1%	92.2%	86.0%	88.6%	90.8%	88.5%	87.8%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.7 Containerization Rates by Route for Cluster 7

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			51.0%	45.6%	41.3%	31.3%	44.2%	31.3%	30.4%	38.3%	
Hong Kong			30.1%	24.9%	43.9%	35.3%	35.5%	34.6%	36.6%	27.9%	27.6%
Indonesia	53.0%	14.2%		66.4%		33.3%	55.3%	50.4%	53.8%	36.9%	37.9%
Japan	30.7%	44.2%	34.9%		33.2%	33.4%	39.3%	33.8%	31.8%	38.8%	49.6%
Malaysia	31.3%	37.1%		20.2%		37.6%		31.1%	28.2%		20.9%
Philippines	26.4%	63.5%	40.8%	14.1%	70.8%		59.3%	22.8%	25.0%	26.7%	26.8%
Singapore	60.3%	41.8%	32.7%	27.2%		26.8%		23.5%	31.7%	35.2%	39.5%
South Korea	42.9%	43.6%	38.0%	53.8%	36.7%	31.5%	44.0%		31.8%	35.9%	31.5%
Taiwan	35.5%	29.4%	31.5%	35.9%	23.8%	27.5%	35.9%	25.5%		23.9%	24.7%
Thailand	18.8%	29.6%	34.3%	49.6%		22.3%	57.0%	61.4%	43.9%		32.3%
Vietnam		55.5%	54.9%	42.5%	79.1%	25.7%	37.4%	33.2%	63.2%	20.0%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.8 Containerization Rates by Route for Cluster 8

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			31.2%	16.1%	36.0%	34.5%	45.1%	38.3%	8.7%	29.9%	
Hong Kong			18.1%	28.3%	16.7%	14.9%	23.2%	23.3%	11.4%	27.6%	9.6%
Indonesia	18.0%	24.1%		30.2%		31.0%	29.3%	28.4%	31.2%	33.4%	29.1%
Japan	23.0%	15.7%	25.8%		23.7%	21.1%	15.3%	23.7%	14.8%	25.5%	15.9%
Malaysia	25.1%	19.8%		10.8%		16.2%		20.7%	22.1%		29.0%
Philippines	18.3%	9.5%	16.9%	3.2%	10.9%		1.6%	17.5%	5.1%	23.7%	14.8%
Singapore	27.8%	33.4%	29.5%	33.8%		30.8%		25.0%	34.7%	30.4%	26.3%
South Korea	31.6%	30.7%	23.8%	26.3%	27.8%	26.3%	23.1%		32.5%	28.1%	13.0%
Taiwan	31.5%	27.3%	26.2%	21.8%	24.9%	23.0%	28.6%	28.4%		27.5%	27.4%
Thailand	19.3%	22.7%	7.3%	4.1%		9.2%	20.8%	8.4%	20.7%		5.6%
Vietnam		24.4%	20.1%	6.6%	21.3%	10.6%	11.2%	3.4%	21.2%	18.9%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

Table A.III.9 Containerization Rates by Route for Cluster 9

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			83.6%	24.6%	76.3%	75.8%	93.4%	60.9%	67.8%	80.6%	
Hong Kong			95.7%	95.9%	95.7%	95.6%	95.7%	95.7%	88.9%	95.7%	85.0%
Indonesia	94.6%	95.7%		54.8%		95.7%	95.4%	82.3%	89.3%	95.7%	95.2%
Japan	78.0%	95.3%	94.3%		94.0%	93.8%	95.7%	87.5%	91.8%	95.0%	93.9%
Malaysia	89.0%	95.6%		33.2%		92.2%		69.9%	73.1%		92.8%
Philippines	51.6%	95.8%	95.7%	22.1%	91.2%		95.7%	78.5%	95.6%	95.7%	95.4%
Singapore	94.1%	95.7%	94.7%	95.7%		80.9%		95.6%	95.7%	55.5%	95.6%
South Korea	95.2%	95.7%	95.6%	71.9%	95.7%	95.7%	95.7%		95.7%	95.7%	94.1%
Taiwan	95.4%	95.0%	94.5%	85.3%	90.4%	71.9%	95.7%	95.7%		95.3%	95.7%
Thailand	83.5%	95.8%	94.8%	36.8%		95.0%	94.5%	83.6%	95.7%		89.8%
Vietnam		86.7%	65.7%	30.5%	79.7%	37.5%	94.3%	27.2%	95.7%	95.7%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates of pairs of countries with common land borders are excluded.

Table A.III.10 Containerization Rates by Route for Cluster 10

	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand	Vietnam
China			3.1%	4.4%	4.7%	6.7%	7.0%	5.7%	5.5%	5.6%	
Hong Kong			12.0%	16.4%	12.0%	9.6%	13.1%	12.0%	23.2%	12.0%	12.0%
Indonesia	23.6%	15.5%		5.8%		26.1%	21.3%	12.5%	19.0%	15.8%	25.9%
Japan	21.9%	14.0%	11.7%		8.0%	12.7%	10.7%	12.8%	14.4%	32.3%	13.6%
Malaysia	13.8%	13.4%		15.3%		26.9%		14.8%	15.2%		13.6%
Philippines	15.4%	12.2%	15.2%	19.9%	16.4%		16.9%	11.5%	10.6%	11.4%	12.2%
Singapore	2.7%	4.5%	5.3%	8.8%		4.0%		8.7%	7.4%	6.9%	5.7%
South Korea	3.3%	11.8%	4.4%	5.1%	5.0%	3.4%	5.6%		6.7%	6.6%	4.0%
Taiwan	4.2%	12.0%	8.5%	12.9%	8.5%	7.7%	8.2%	8.3%		8.7%	2.4%
Thailand	4.0%	11.6%	10.5%	11.8%		9.0%	6.8%	9.4%	10.3%		4.9%
Vietnam		12.0%	11.5%	12.0%	12.2%	12.0%	11.9%	12.0%	12.0%	13.2%	

Note 1: Containerization rates are average rates from 2010 to 2014.

Note 2: Containerization rates for pairs of countries with common land borders are excluded.

APPENDIX IV

QUESTIONNAIRE USED IN INTERVIEW SURVEY

Survey Questionnaire for "Study on Bulk Cargo Containerization"

1. At the Port of Los Angeles and the Port of Long Beach, bulk cargoes such as ferrous scrap, soybeans, and animal feeds are often containerized, and bulk shipping and container shipping coexist for these goods. Please let me know when containerization of these goods began and how it has progressed. In addition, please let me know the main destinations for these cargoes.

2. If you know of any other examples of BCC, please let me know.

3. Is my understanding that the progress of BCC can be attributed to (1) innovations in loading equipment and facilities and (2) a surge in freight rates in the mid-2000s (and many shippers' changing perceptions regarding shipping in small units) correct? If you are aware of other factors that are relevant in explaining the progress of BCC, please let me know.

4. Who do you think has led the BCC of ferrous scrap, soybeans, and animal feeds? Please let me know if you have any other thoughts in this regard.

   Ferrous scrap
   a. Shippers
   b. Logistics providers (including forwarders) or trading companies
   c. Consignees
   d. Shipping companies
   e. Others

   Soybeans
   a. Shippers
   b. Logistics providers (including forwarders) or trading companies
   c. Consignees
   d. Shipping companies
   e. Others

   Animal feeds
   a. Shippers
   b. Logistics providers (including forwarders) or trading companies
   c. Consignees
   d. Shipping companies
   e. Others

5. When the transportation mode shifts from bulk shipping to container shipping, how will transportation contracts between shipping companies engaged in bulk shipping and shippers change? (multiple answers are allowed)

   a. Shipping companies will enter into a contract directly with the shippers (i.e., there is no change), but the contracting section in the shipping company will change to a liner section for containerized bulk cargo, whereas the contracting section in the shipping company will not change and the tramper section will engage in the bulk transportation.

b. One contracting party will change to containerized cargo. The new contracting party is a forwarder or Non Vessel Operating Common Carrier (NVOCC), and the relationship becomes indirect for containerized cargo. That is, shippers (or consignees) enter into contracts with the tramper section of the shipping company for bulk cargo, whereas shippers arrange deals with the forwarder or NVOCC for containerized cargo.
c. One contracting party will change to containerized cargo. The new contracting party is another shipping company that transports containerized cargo.
d. Other parties, e.g. shippers (consignees), will tend to enter into contracts with shipbrokers, and BCC will change.

6. A bulk carrier can carry a large volume of cargo, so if a shipper (or consignee) wanted to send cargo by bulk carrier, they would need to sign a longer-term contract. Is my understanding that shippers (consignees) must enter into longer contracts for bulk shipping than for container shipping correct? If possible, please let me know what the typical contract length is for bulk shipping and container shipping (multiple answers are allowed, given that this may vary depending on the types of goods).

Bulk shipping
a. Beyond one year (goods)
b. One year (goods)
c. Fixed period shorter than one year (goods)
d. Trip charter (goods)

Container shipping
a. One year (goods)
b. Fixed period shorter than one year (goods)
c. Spot (goods)

7. Because bulk carriers can carry a large volume of cargo, shippers or consignees seem to decide on the share of bulk shipping and container shipping they will use to carry their goods before the trade occurs. If possible, please tell me what form this decision-making takes (multiple answers are allowed).

a. The shares (in terms of cargo volume) of bulk shipping and container shipping are decided at the beginning of the year or quarter as part of the shippers' (or consignees') management plans (i.e., shippers (or consignees) regularly make decisions regarding the volume carried by each transportation mode).
b. Shippers (or consignees) do not make any decisions regarding the volume carried by each transportation mode, but logistics providers do so at the beginning of the year or quarter (i.e., logistics providers regularly make decisions regarding the volume carried by each transportation mode).
c. The shares (in terms of cargo volume) of bulk shipping and container shipping are decided by shippers (or consignees) when shippers collect the cargo.
d. The shares (in terms of cargo volume) of bulk shipping and container shipping are decided by logistics providers when shippers collect the cargo.
e. Other

8. Please let me know your company's view of BCC for goods other than ferrous scrap, soybeans, and animal feeds.

a. These are promising new cargoes, and I think that shippers or other relevant parties should pursue these opportunities.
b. It depends on the market situation and the kinds of goods. Some of the bulk cargoes are promising, and I think that shippers or other relevant parties should explore the possibilities related to these cargoes.

c. I think the potential of these cargoes is uncertain, but I think that shippers or other relevant parties should respond to shippers' or consignees' needs.
d. Even though shippers or consignees might indicate demand for BCC of these cargoes, I do not think that shippers or other relevant parties should carry these cargoes.*
* Please let me know what your concerns are.
e. We never carry these cargoes.*
*Please let me know why not.
f. Other

9. Are recent innovations such as automation of port services and digitization of trade procedures likely to enhance the progress of BCC?

a. They have the potential to enhance the progress of BCC.
b. They have the potential to enhance the progress of BCC to some extent for some goods.
c. They will probably not have any effect on the progress of BCC.

Please let me know the reason(s) for your answer.

10. What kinds of innovation or development concerning container shipping or logistics do you think have the potential to enhance the progress of BCC?

11. What problems need to be solved to advance BCC? Please circle the issues you think are important in Table A.IV.1 below (multiple answers are allowed).
If you are aware of any other challenges, please write these down.

Table A.IV.1 Challenges and Specific Issues regarding BCC

Challenge	**Issues**
Container availability	Location and characteristics of goods
Container preparation	Pre-use cleaning (to avoid contamination) Use of liners Post-use cleaning Dedicated containers
Container loading, unloading, and transloading	Bulkers difficult to load horizontally Vertical loading/unloading (equipment) Transloading issues
Cargo weight	Limitations to about 30 tons (40-foot containers) 20-foot containers (26–28 tons) preferable
Weight distribution	Container loads (10–14 tons per TEU) Trade imbalances necessitate mitigation strategies
Land requirements at port terminals	Container shipping more consume port space (four times more than bulk shipping)
Existing distribution channels	Considerable sunk investment (transport modes and terminals) Established distribution practices Modal shift inertia